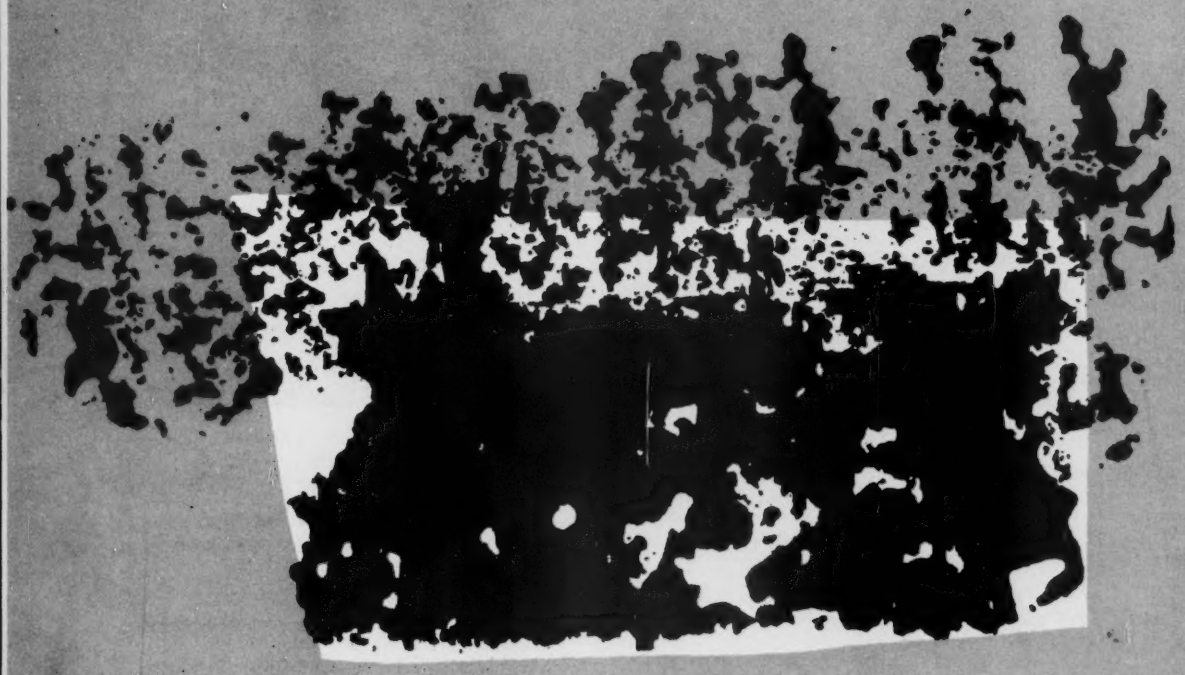
tech engineering news



april 1954

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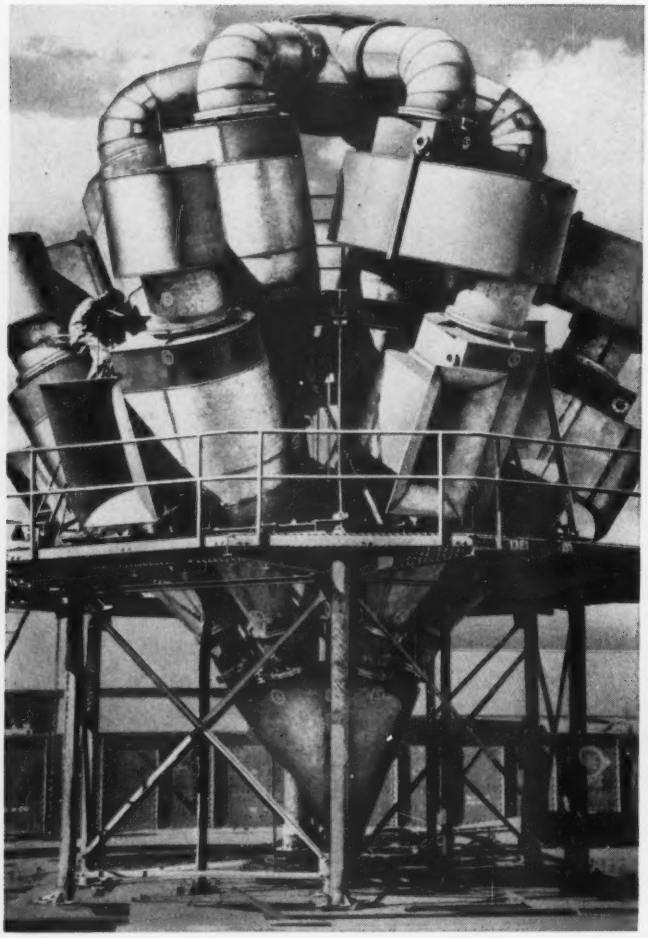
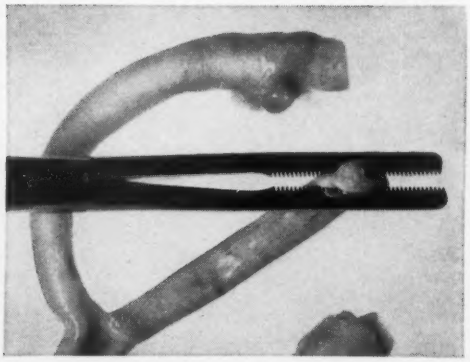


Visitor from Outer Space? No, despite its strange, other-worldly appearance, this is no product of extra-terrestrial intelligence, no flying saucer. It's a perfectly practical, very down-to-earth catalyst collector in a large petroleum refinery. Noteworthy, however, is the extensive use of USS Stainless Steel in its fabrication . . . to provide corrosion resistance combined with great strength.



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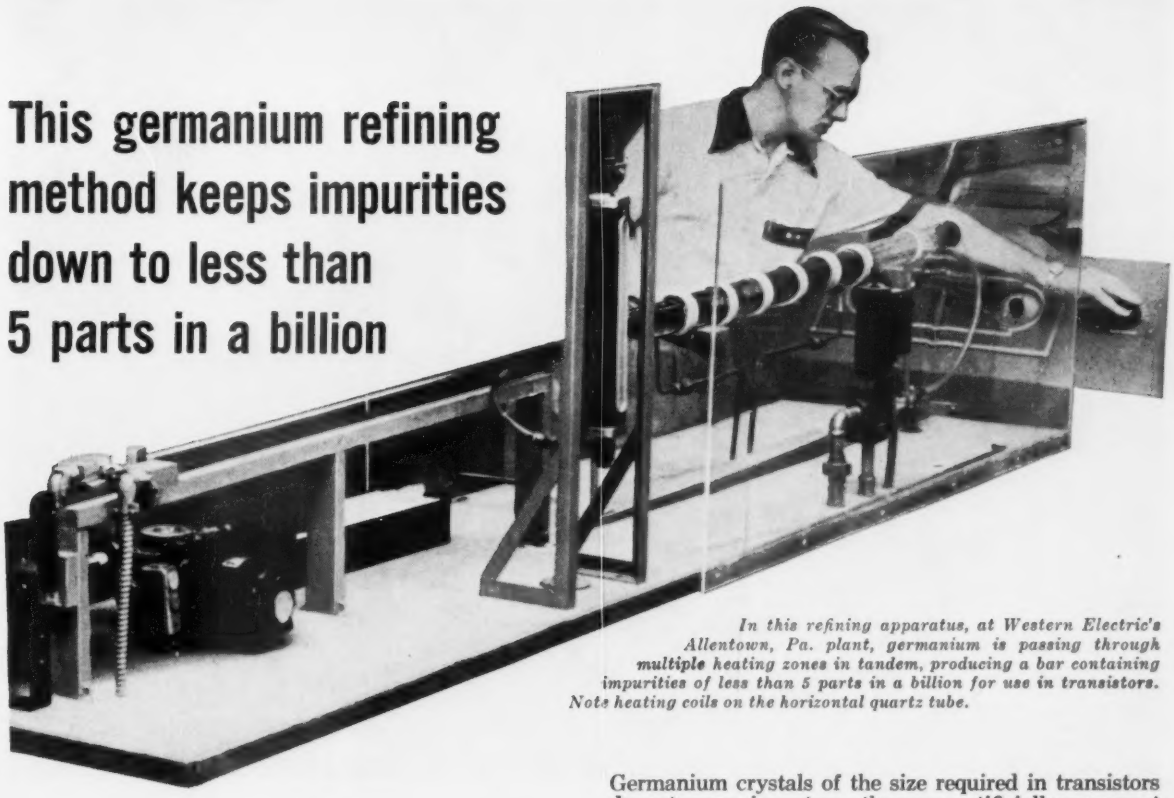
This germanium refining method keeps impurities down to less than 5 parts in a billion



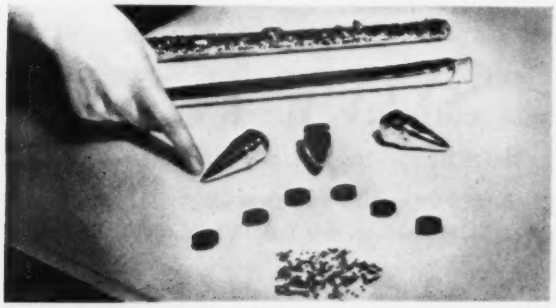
In this refining apparatus, at Western Electric's Allentown, Pa. plant, germanium is passing through multiple heating zones in tandem, producing a bar containing impurities of less than 5 parts in a billion for use in transistors. Note heating coils on the horizontal quartz tube.

A new method of metal refining, currently in use at the Western Electric plant at Allentown, results in the production of germanium that is better than 99.9999995% pure – the highest degree of purity ever attained in a manufactured product.

The need for germanium of such exceptional purity came about when research by Bell Telephone Laboratories in the field of semi-conductors led to the development of transistors, which are manufactured by Western Electric.

The transistor is a tiny crystal device which can amplify and oscillate. It reduces space requirements and power consumption to a minimum.

Various forms which germanium takes before being used in transistors are shown in this photo. Bar at top is an ingot of germanium after reduction from germanium dioxide. Next is shown the germanium ingot after the zone refining process used by Western Electric. Below the ingots are shown 3 germanium crystals grown by machine, 6 slices cut from these crystals, and several hundred germanium wafers ready for assembly into transistors.



Germanium crystals of the size required in transistors do not occur in nature; they are artificially grown at Western Electric. At this stage in transistor manufacture, other elements are introduced in microscopic quantities to aid in controlling the flow of electrons through the germanium. But before these elements can be introduced, it is necessary to start with germanium of exceptional purity, so that the impurities will not interfere with the elements that are deliberately added.

So Bell Telephone Laboratories devised an entirely new method of purification, known as zone refining, which was developed to a high-production stage by Western Electric engineers.

In zone refining a bar of germanium is passed through a heat zone so that a molten section traverses the length of the bar carrying the impurities with it and leaving behind a solidified section of higher purity. By the use of multiple heating zones in tandem, a number of molten sections traverse the bar. Each reduces the impurity content thus producing a bar which contains impurities in the amount of less than five parts per billion.

Because of the importance of the transistor in electronics, the zone refining process – like so many other Western Electric developments – has been made available to companies licensed by Western Electric to manufacture transistors.

This is one more example of creative engineering by Western Electric men. Engineers of all skills – mechanical, electrical, chemical, industrial, metallurgical, and civil – are needed to help us show the way in fundamental manufacturing techniques.

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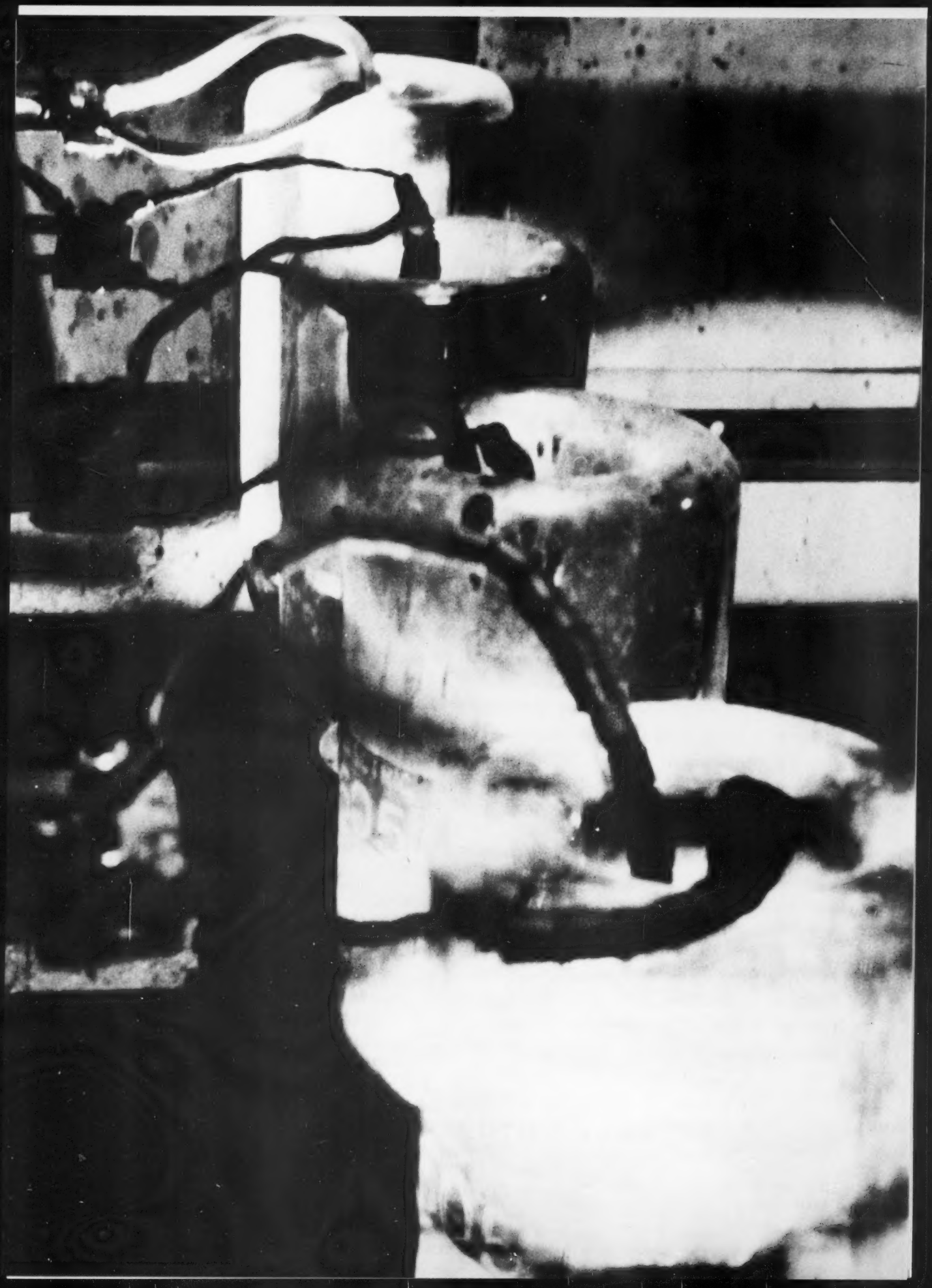

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Flashing Tubes

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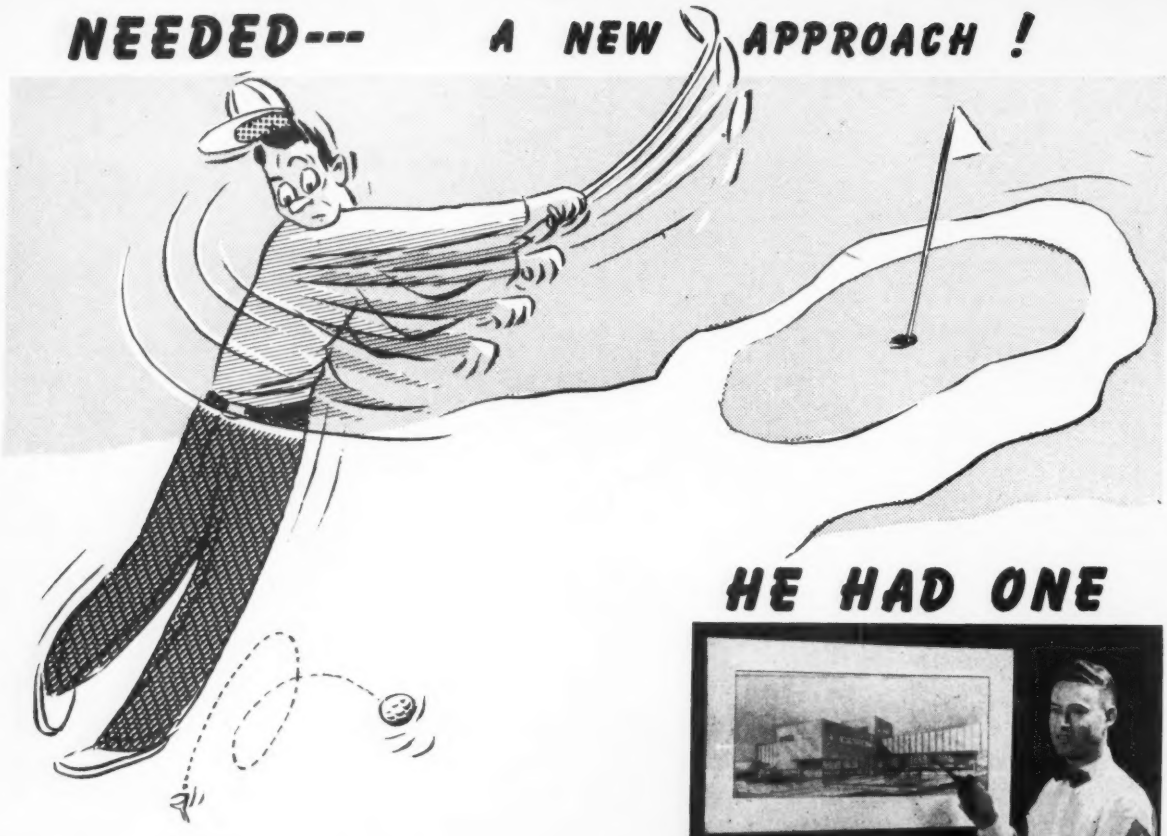
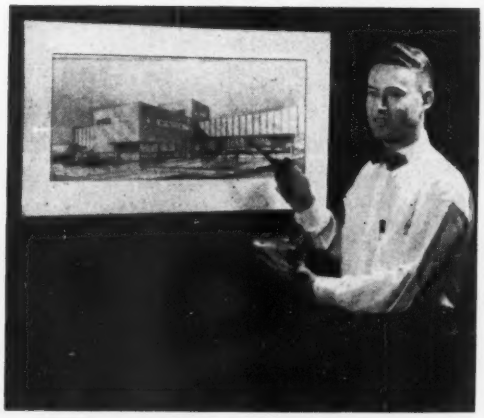
NEEDED--- A NEW APPROACH !



HE HAD ONE



LAMAR A. RAMOS, JR.,
Sr. Design Engineer—Airplane Engineering Division
B.S.P.E. Lousiana State U. 1941
B.S.A.E. Georgia Inst. of Technology 1947

Seen here examining the architect's sketch of our recently completed Wind Tunnel, Lamar's approach in solving complex and often unique aerodynamic problems has marked him as an engineering asset to M.A.C.

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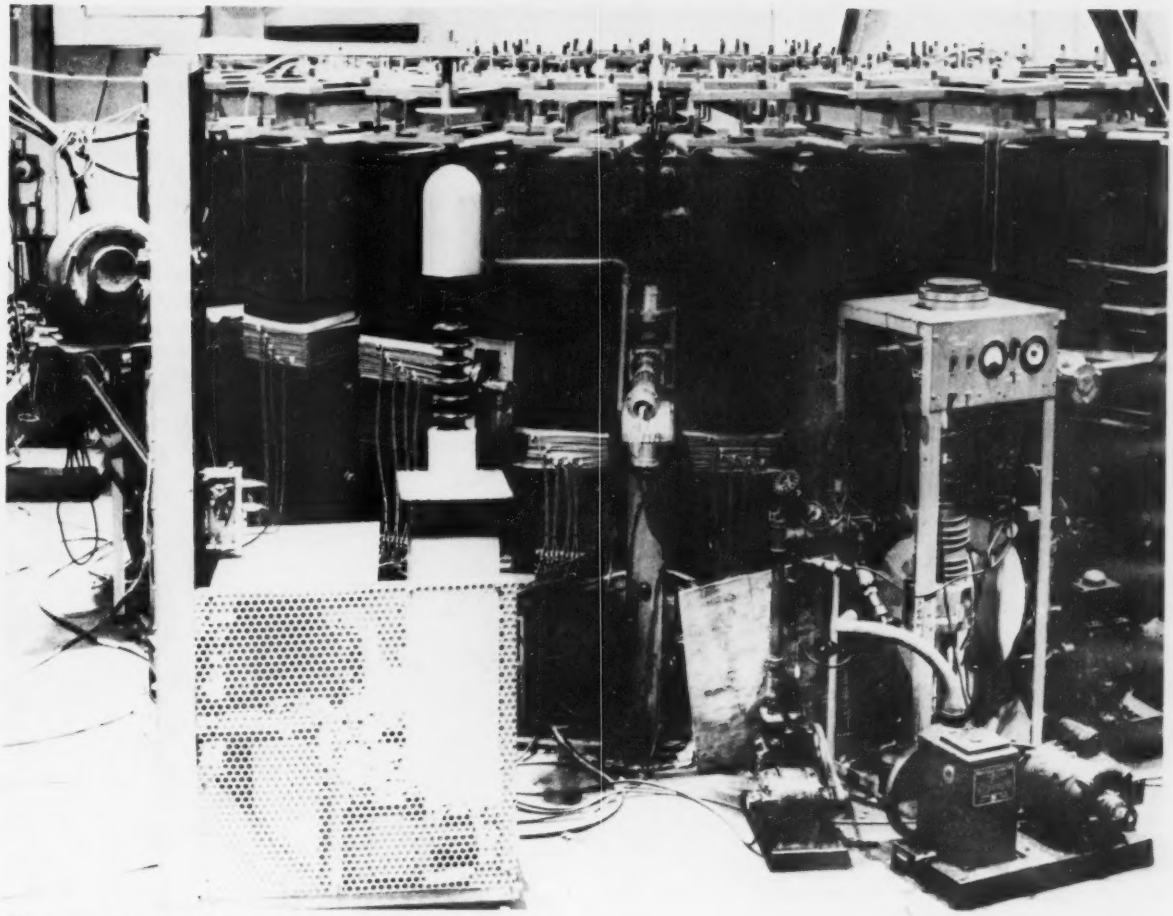
the m.i.t. synchrotron laboratory

by Allen C. Langord, '57

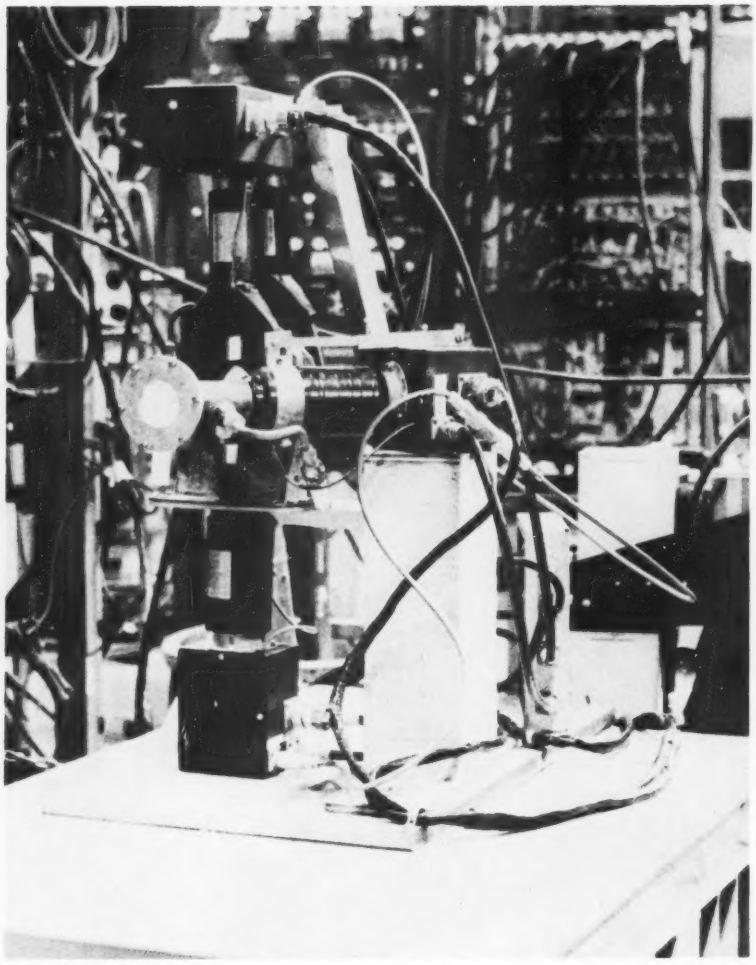
Photographs by Malcolm MacLeod, '55

The importance of nuclear physics today creates a great necessity for the production of high energy elementary particles, for, indeed, energies up to 20 mev are needed to investigate even the simpler processes of the atom and energies above even 138 mev are needed for the artificial production of π mesons. It is because of this urgent need of high energy levels that high energy particle accelerators have been developed, among them being the cyclotron, the betatron, the synchrotron, and others. Let us now, for a moment, recall how elementary charged particles behave under the influence of electric and magnetic fields. A low energy particle introduced into a constant, uniform field accelerates uniformly—its energy and speed obviously increasing all the time. As the particles gain energy their mass increases, and further acceleration forces them closer and closer to the speed of light, never, however, quite reaching it. When a particle nears the speed of light, electric fields no longer are able to increase the particle's speed. Accelerators also employ strong magnetic fields to aid in accomplishing the desired results in the particular instrument, and if we have a constant uniform magnetic field with particles travelling in it, the resulting force in the system will be at right angles to the velocity of the particles, as well as to the magnetic field itself.

The control console coordinates the operation of the entire machine.



The general layout of the magnet looking down.



The gun injects electrons into the vacuum chamber.

A magnetic field varying with time is always accompanied by an induced voltage and is given by Faraday's law, that $\frac{d\Phi}{dt}$=emf, where $\frac{d\Phi}{dt}$ is the change of flux with respect to the time and emf equals an electromotive force. Various combinations of these ideas are employed in the construction of high energy particle accelerators. We shall confine our discussion, here, to only the performance of the betatron and of the synchrotron, for the synchrotron is, in essence, a "glorified betatron" with, of course, some peculiarities all to itself.

Betatron Action

A betatron accelerates electrons and is based on the principle of magnetic induction, with the accelerator having exactly the same principle as an AC transformer, the difference being that the output current in a transformer flows into a secondary winding, while the "secondary" current is actually a beam of electrons flowing into a vacuum (as in the case of a betatron), with the beam forced to travel in a circular orbit because of a strong magnetic field. The magnet of the betatron not only provides the electromotive force, but also a focusing force, and it is this double task that imposes the requirement that certain equilibria be maintained between the forces. Energy is radiated by the electrons in their simultaneous high speed and radial acceleration, and, as the energy level rises, the electromotive and focusing forces become "unbalanced;" this, then, upsets the cquilibria criteria of the forces and the betatron is thus limited to a certain maximum energy level, the maximum level being around several hundred million electron volts. Referring to the simplified diagram we may trace the action of the betatron as follows: into a hollow doughnut shaped "vessel" evacuated to a very low pressure, electrons are injected by means of an electron gun, (this takes place at the instant the magnetic field passes through its zero value). Electrons are thus accelerated by induced emf to the maximum value for which the particular machine is built. Then the electrons are forced to move off their circular path in toward the center, by the instantaneous addition of a slight magnetic field, where they strike a tungsten target. When the electrons strike the target, their energy is converted into X-rays of very high energy.

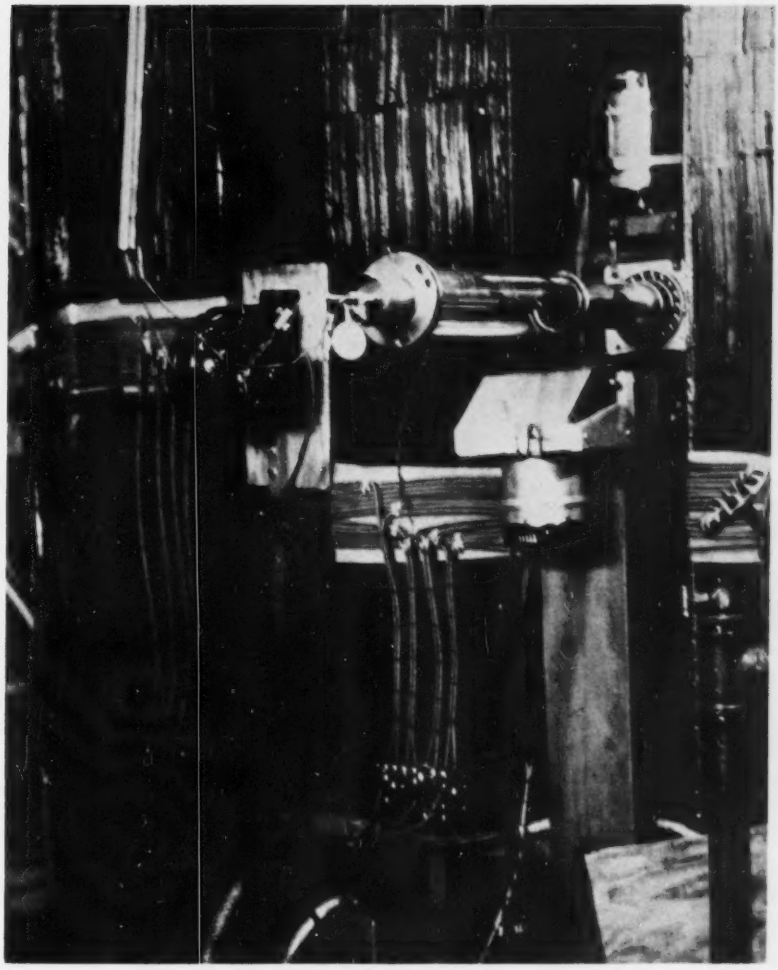
Synchrotron Action

Turning our attention, now, to the synchrotron, we discover that the synchrotron is really nothing more than a betatron to which has been added a constant frequency rf generator. With the synchrotron, then, electrons can be accelerated to much higher energies than are possible with the betatron (for magnets of identical specifications). In action, the synchrotron accelerates electrons, by betatron action, to about 2 mev, and, with the assistance of the rf section, the electrons are further accelerated to a much higher energy level. For the M.I.T. sychrotron this level is 340 mev. Let us further consider the action of this rf generator. If, for example, the magnetic field of the synchrotron were kept constant, the electrons would keep rotating at an energy value corresponding to that of the field; with these conditions imposed, the electrons would cross the accelerating gap at the time when the accelerating voltage was zero. However, as the magnetic field increases, the orbit gets smaller; consequently, the time it takes for a "complete trip" likewise decreases. Since the

electron will now reach the accelerating gap slightly sooner than illustrated in the case above (where it arrived at the same time), there is an acceleration voltage across the gap. In other words, there is an added "pull" on the electron by the rf cavity, and it is this condition which further accelerates the electron; the faster the field is increasing the greater will be the acceleration of the electron, and hence, the greater will be the relative energy of the particle. This will only be true, however, if the rf voltage is large enough and $d\Phi/dt$ is great.

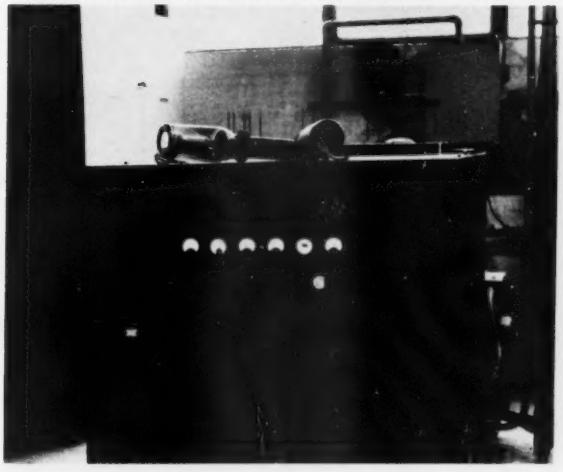
The M.I.T. Synchrotron

Consider now the component parts of the synchrotron and then we shall further discuss their individual functions in more detail. The M.I.T. synchrotron consists of 24 C-shaped sections which comprise a circular magnet. A rectifier system changes the AC from the power lines to DC; this DC is stored in a capacitor bank and is discharged at the proper time, by appropriate electronic devices, into the magnet coils by means of electronic tubes called ignitrons, which can be thought of as electronic switches. A doughnut shaped vacuum chamber is placed in the "hollow opening" of the C's and through a "hole" in the side projects the electron gun. There is a certain section of this chamber in which a rf tuned cavity resonator is controlled and fed by an external rf oscillator and by appropriate timing circuits respectively. The complete operation of the instrument is coordinated, controlled, and monitored at the console.



A closeup of the gun showing in detail the positioning motors.

The rectifier bank converts AC from the line to DC.



The Magnet

The magnet is laminated to reduce eddy currents and there are, in the whole magnet, two elongated C-sections that provide for two possible beam exits which are at right angles to each other. In addition, each section is spanned by a small flux bar of a highly permeable silica steel which carries the changing magnetic flux during the betatron cycle. The peak magnetic field is about 11,430 gauss; the peak magnetomotive force is 81,000 turns.

Magnet Controls

The capacitor bank has a total of 1017 mfd. which is obtained through several series and parallel combinations. The magnet is pulsed (at a certain predetermined rate) by means of the capacitors and the ignitrons. Because of eddy currents and hysterisis inherent in the twenty-four C-sections, azimuthal corrections must be made so that the beam is properly positioned at all times, which, of course, is of prime importance. These correction windings are powered from the sixty cycle line and are synchronized such that the cor-

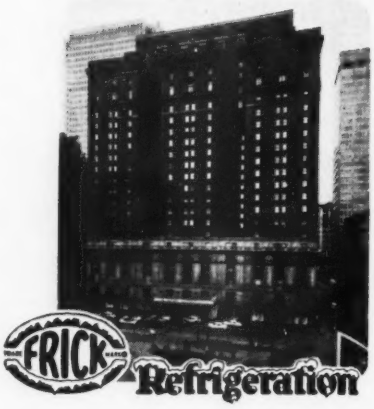
rection currents are 90 degrees out of phase with the magnet current. Operation of the synchrotron without extremely careful adjustment of these trimmer coils is futile. One consolation, though, is that once the adjustments are made on these trimmers, they do not vary from day to day.

The Vacuum Chamber

The vacuum chamber consists of twelve sections a specially prepared slip-cast steatite with a dielectric constant of nine. In the accelerating chamber there is the possibility of electrons striking the chamber wall, thereby eventually building up charges which ultimately have an adverse effect upon the electrons already in the stable orbit, and to completely eliminate this possibility, a resistor network leads all the electrons striking the tube wall to ground. To monitor the amount of electrons striking the chamber wall a cathode ray oscilloscope is connected across this network. A vacuum of .5 to 1.0×10^{-5} mm. Hg is maintained by means of a mechanical fore pump and an oil diffusion pump system. To check the vacuum, the system employs both a thermocouple gauge (good from 1mm. to 10^{-3} mm. Hg) and an ionization gauge which is valid for pressures below 10^{-2} mm. Hg. A power oscillator is used to drive the rf resonator. The resonator is in one section of the vacuum chamber which is silver coated inside and out at this point. Also the oscillator output is modulated in order to control the size, shape, and timing of the rf pulse.

The Gun

The electron gun emits electrons into the accelerating chamber in a direction tangential to the electron orbit and for a specific energy level of injected electrons there is also a particular level of the magnetic field; this is, needless to say, to ensure that the electrons will be captured by the initial betatron action. With higher injection values, there must be a correspondingly higher field value, but it is usually desirable to have these higher values, for the intensity of the synchrotron increases. The cathode of the gun is constructed of sintered thoria and molybdenum and is directly heated. It is covered on all sides by a molybdenum shield (which is held at cathode potential). It is most interesting to note that the gun can, literally, be positioned by automatic control from the console, and the controls vary the radial, aximuthal, and rotational positions. Concerning the beam ejection: there are three methods of making the electrons strike the target, depending on the length of pulse desired. In the first, magnetic coils affect the electron beam by disturbing the field. This gives an X-ray pulse of about one microsecond and is used for the detection of mesons by decay electrons. The second method employs the turning off of the oscillator just before the field (maximum) is reached, thus causing the electrons to spiral in and hit the target (because the magnetic field is still increasing continually.) This gives an X-ray pulse of about ten microseconds and is finally used for cloud chamber work and nuclear plate studies. The third and final method is to turn the oscillator off just after the peak of the magnetic field so that the radiation loss of the electron (recall, momentarily, the brief discussion on electron radiation) just overbalances the rate of decrease of the magnetic field and the beam will slowly spiral into the target. This gives a pulse of from 100 microseconds to 1000 microseconds and is used for counting studies.



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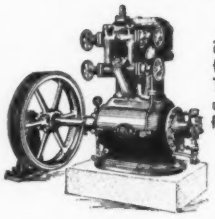

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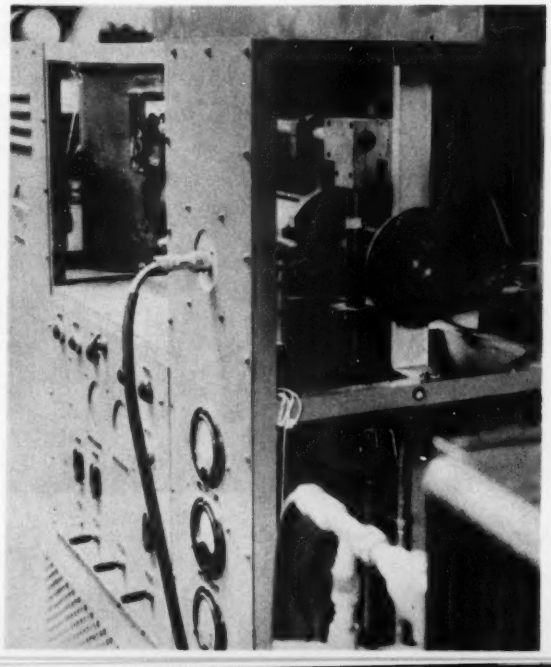
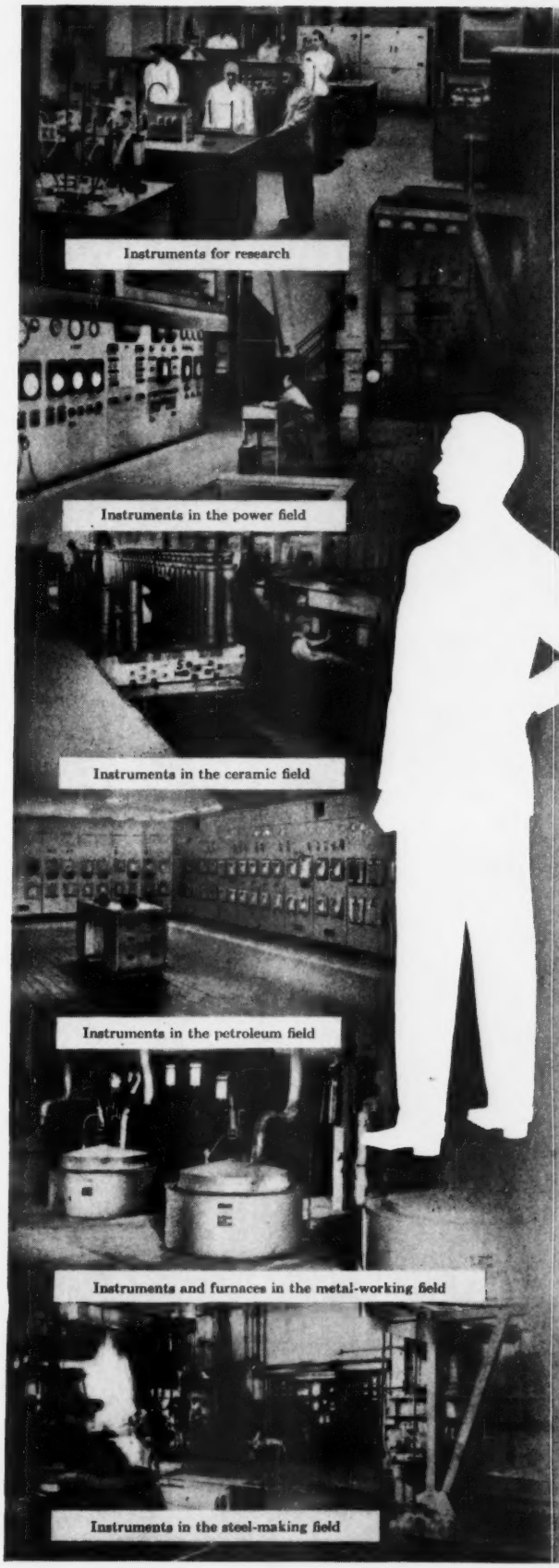
Measurement

All of the various functions are timed with a complex electronic system, but again are completely under control of the operator at the console. In making measurements after the target has been struck, the scientists and technicians must

The ignitrons act as electronic switches.

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develop intricate apparatus with which to measure accurately the results of the particular experiment. Furthermore, the equipment is different for each experiment. In conclusion let us look at the accomplishments of the M.I.T. Synchrotron Laboratory and also discuss the work now in progress. Already the measurement of the decay of the pi meson has been made. In addition the measurement of the mass of the pi meson and mu meson, of the abundance of the positive and negative mesons, of the detection of neutral mesons, of the detection of natural mesons, and of the measurement of the excitation of various nuclei, have been accomplished. Too, they have measured the spectrum electrons into which the mu mesons decay radioactively, and they have worked with the production of mesons by X-rays from hydrogen and other elements. Their current work includes investigating gamma ray scattering from nuclei, which, incidentally, is analagous to the classical X-ray exploration of the atom, and the building of a liquid hydrogen and deuterium target to examine the effects of bombarding these targets with the high energy electrons.

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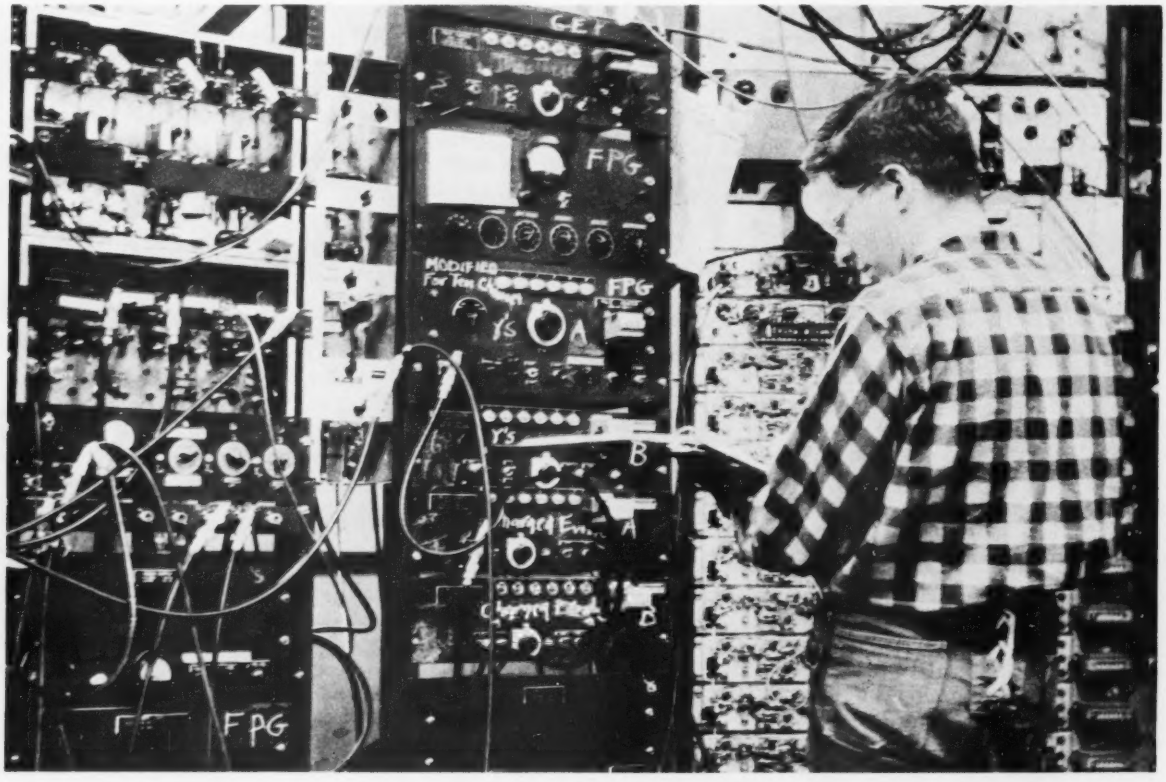

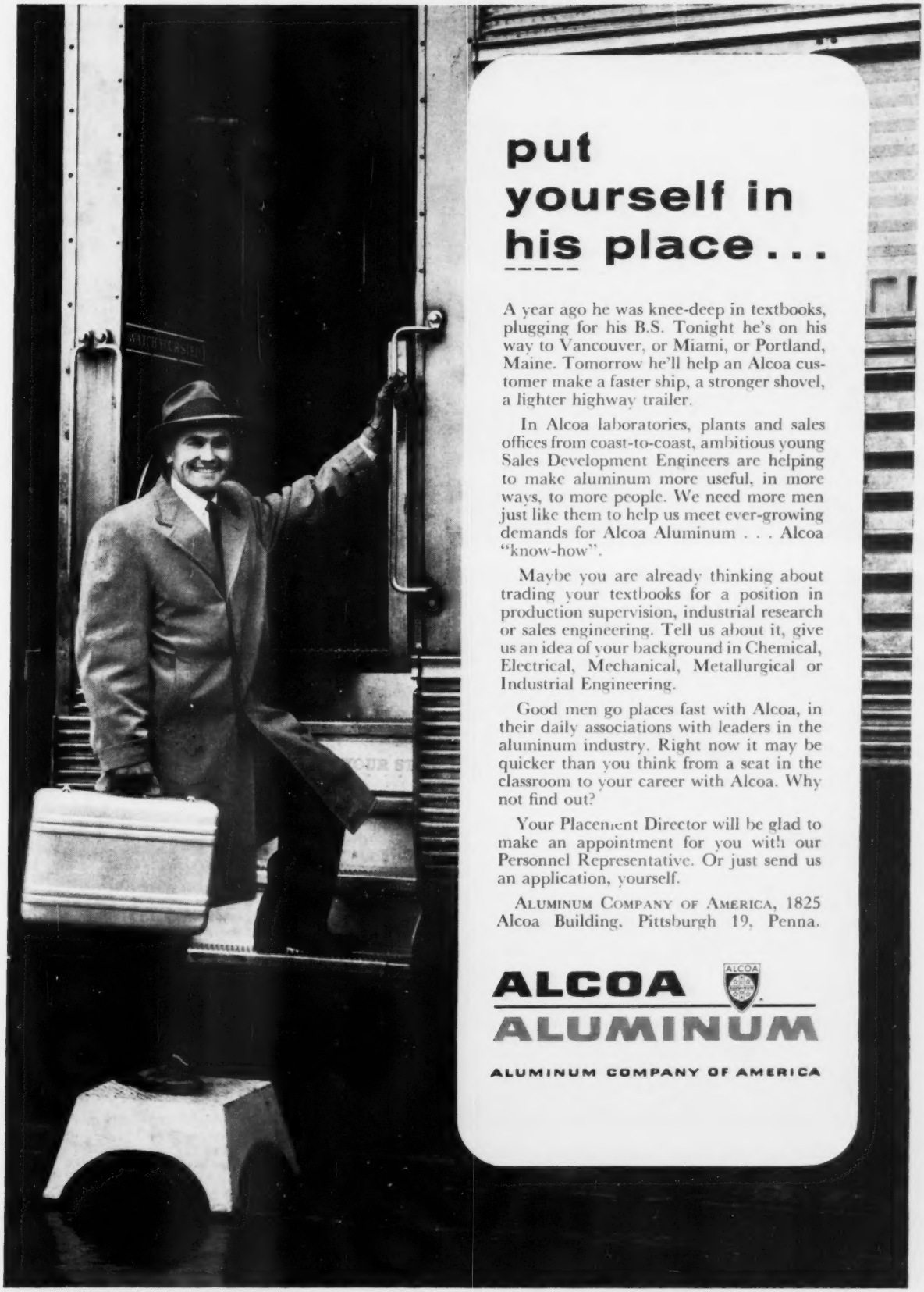

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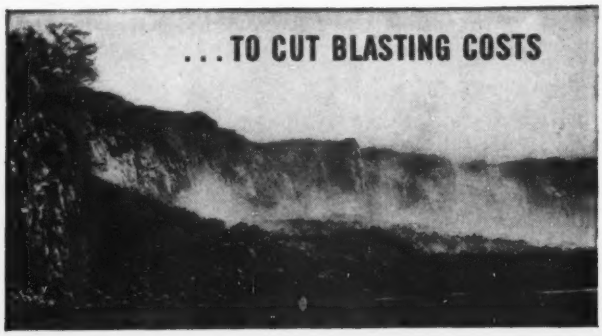

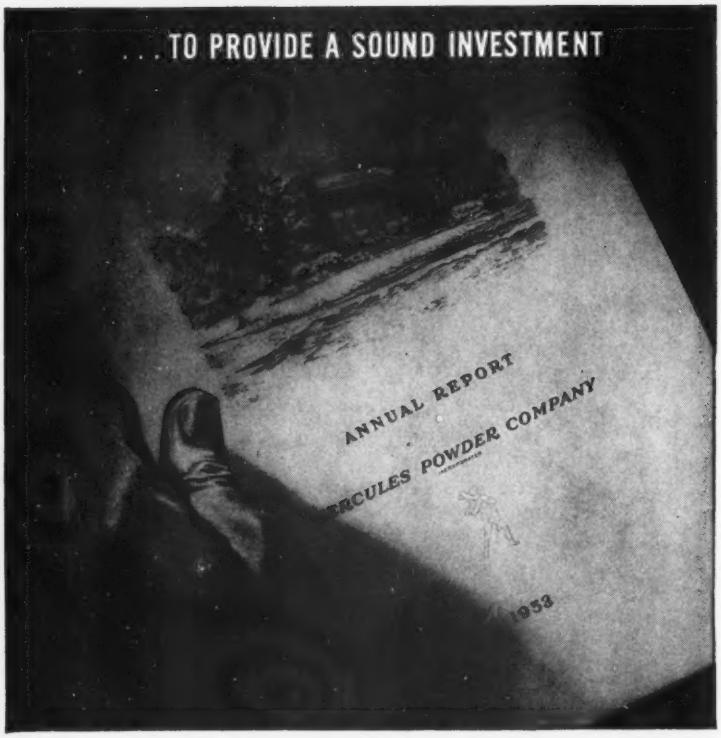

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from the editor's notebook

Democracy -- HA!

Among the many posters about Tech during the last onslaught of student government elections, the one that struck us as most disgusting was that of one enterprising candidate soliciting all students to "Exercise your right. Vote today." Apparently this candidate has been impressed with the fine American tradition of democracy and has been brought up to believe that if one has the right to vote, he should vote. Even ignorance of the candidates and their platforms is no excuse for not voting; if it is your privilege, use it.

TEN believes that democracy should mean more than just voting when it comes time to vote. It should mean keeping abreast of the issues and voting only if one has a reason to vote . . . other than just to exercise a right. In the case of student government, however, there are generally no issues, and to top that off, for what issues there are, most of the student body does not keep informed but remains in blissful ignorance, caring less about forty-five cent fines and more about sex, etc. Why should any candidate ask these students to vote? They would not know whom they are voting for; they would not know why they are voting for them; they just wouldn't care. But surprisingly a large number of them vote in ignorance in, what they believe, is the good old fashioned patriotic way of supporting democracy. Instead, they abuse democracy.

It is because of these many unenlightened voters that student government elections are able to roll up such a large turnout as thirty-five per cent. Very few of those voting have any good reason to do so. Considering that only a small portion of this thirty-five per cent has a valid motive for voting, and that there are as many as four candidates running for a single office, and that voting is on a preferential basis, it is apparent that the winner of any single student government election has very few voters behind him.

What can be done to remove this abuse of democracy? Should we eliminate student government? Possibly this is a solution, but at any rate, we should eliminate any association between the ideal of democracy and the institution of student government.

D. E.

The New T.E.N. Four

The fine traditions that T.E.N. has observed in the past will be carried on in the future by four stellar members of the present staff. Carrying the main load as General Manager will be **Don Eckhardt, '55.** The literary department will be headed by Editor-in-Chief **Karl Ludvigsen, '56** of sport car fame. **Tom Cantrell, '55,** this year's Advertising Manager, will be Managing Editor and **Mike Ginsberg, '55** will preside over the books as Business Manager.

P. E.

T.E.N. Staff Member going down to make dangerous illegal tap.

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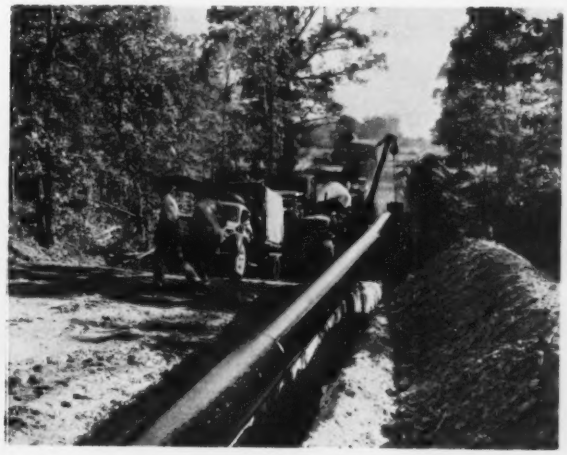

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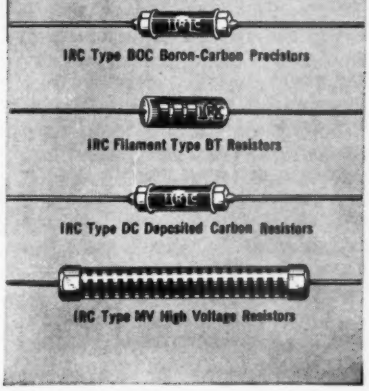

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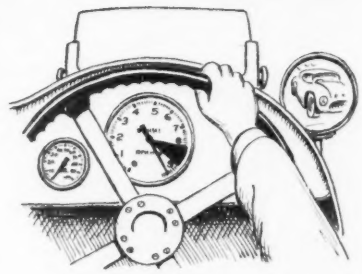

A Comprehensive Survey Of The Most Popular Foreign Economy Cars

by Stefan Habsburg, '55

Stefan Habsburg has long been interested in both the technical features and performance characteristics of the small European cars that are now so popular in the United States, and this interest well qualifies him to write an authoritative article on the subject. He has driven both the Morris Minor and the Volkswagen over 10,000 *miles, and here gives the kind of report that can be written only by a man who has lived, eaten, worked and slept in his car.*

K.E.L.

I want to shoot the breeze about three of the small foreign cars presently available on the American market. Two of them are British, the Morris Minor and M. G. Magnette, and the third is the German Volkswagen. They are all distributed in this area by Foreign Motors, Inc. of Boston.

These three cars have few things in common. They are four seaters and have four-cylinder engines of less than one and one half litres displacement, but the similarity ends with this. Let us look at them in more detail, first taking into consideration the Morris.

The little Morris Minor was introduced at Earl's Court in October, 1948. The compact four seater was powered by an L-head 919 c.c. four-cylinder engine. This conservative (6.5 to 1 compression ratio), but reliable power plant remained substantially unchanged for four years. In 1949 a water-pump was added for better cooling circulation, which also permitted the installation of a warm water heater. 1953, however, brought significant changes. Austin and Nuffield merged. Although their lines continued unchanged in appearance, Morris adopted the smaller (800 c.c.), but more efficient Austin A-30 engine and gearbox. Nominal output of the smaller motor is actually two horsepower more than the old one. From the driver's standpoint there is really no marked difference in performance. Power is transmitted through a single plate clutch and a standard four speed gearbox.

Of much greater interest than the rather conventional little mill is the Morris chassis. It is an ingenious combination of frameless mono-construction and bolt-on fenders. Most of the body components, including the floor, top, trunk, and firewall are welded together into a single self-carrying unit. This makes the car both light and torsionally rigid. Fenders, doors, hood, and trunk lid are bolted onto this skeleton, making repairs and replacements easier. In the rear the Minor is sprung by conventional semi-elliptics and double-acting hydraulic shock absorbers. The front end, however, is a remarkable piece of engineering from the draftboard of Alex Issigonis, one of England's most original designers. A round torsion bar mounted parallel to the frame on either side gives the desired spring medium. The rear of the bar is bolted to a crossmember approximately below the driver's feet. At the front it is splined to a heavy forged arm, which constitutes the lower side of a parallelogram geometry. It is braced against braking loads by a simple rod running from its outer extremity to the front of the chassis. There is no conventional king-pin, but a forged swivel pin takes its place. This swivel pin is of surprising length, reaching almost to the top of the tire. There it is located directly by the arm of a firewall-mounted hydraulic shock absorber. Steering is accomplished by an efficient rack and pinion system. Brakes are Lockheed hydraulic with double leading shoes in front. Although quite simple in execution, the concept of the Morris front end is fitting of a vastly more expensive car.

On first glance the car looks ridiculously small (after all a mere 86 inch wheelbase!). I must say that I was surprised to find that after adjusting the driver's seat it easily accommodated my 6 foot, 200 pound frame. If the owner of one of these cars has particularly long legs the seats can be moved back in the frame by the simple removal and re-installation of four bolts in the provided threaded holes. This somewhat restricts the rear leg-room, but still leaves a fair amount of space for the rear passengers. The seats are upholstered in imitation leather, and are not very soft, but their shape is so nicely thought out that on long trips they are less tiring than some softer ones I have tried. The instrument layout is simple, consisting of a speedometer flanked by an oil-pressure and a gasoline gage. A temperature gage would be desirable, particularly since the engine tends to run below optimum temperature in cold weather. I have seen a very neat installation of a BW gage just below the dashboard, and would seriously advise a future Morris owner to purchase a gage for his car. Underneath the instrument panel there is a generous shelf which supplements the fair sized glove compartment. Like most European cars, the Minor has minute footpedals that are very closely spaced. After some practice I have actually come to prefer this arrangement to the long travel American version. The handbrake is conveniently located between the front seats. This and the exact symmetry of the dash make the car easily adaptable to either right or left hand steering. The four speed and reverse gearbox is easily controlled by a floor mounted lever.

The car starts easily. I have found this true under all weather conditions. Even with a battery so dead that the horn won't produce more than one feeble squawk, it will start at a few turns of the crank or a three foot run down a hill. The first impression on taking this little job on the road is that it has no performance. The little coffee grinder under the bonnet seems to have barely enough pizazz to make the car roll. Once you are used to the Minor you find yourself driving most of the time with your foot to the floor and shifting gears as you slow on hills. The Morris is obviously no red-hot draggin'-wagon, but don't be fooled. It will get you there. Driving on icy roads this mixmaster really shows off. It is indeed a pleasure to go putting up a frozen hill with a mere 26 horsepower while 250 horsepower mobilized bungalows are mounting chains half way up the slope. Generally the car is very slow on hills, with the lower gears coming into play a great deal. I drove one Morris across several 9000 foot passes in the Rockies, carrying a passenger and a backseat and trunk full of luggage. Many sections had to be taken in first gear, but we made it every time! On flat country this toy car is really surprising. Top speed is just barely above 65, yet phenomenal averages are possible. For example, I managed to average (and that's honest average miles per hour) 60 m.p.h. from Torrington, Wyoming to Council Bluffs, Iowa, which, of course, includes Nebraska.

Perhaps the most popular Morris model is the neat two-door sedan.

Long trip comfort is quite good. The suspension gives a remarkably smooth ride for a car of this size. The smallness of the Minor prevents you from changing positions, and an occasional stretch-stop is beneficial. Very few people would want to use the Morris as a distance car, but just for the record I drove from Boston to Jackson, Wyoming and back without experiencing any kind of trouble. Under continued driving in over 110 degree sunshine a peculiar thing happened. The fuel consumption dropped to a miserable (?) 28 miles per gallon. The only valid explanation I could find was that fuel was evaporating through the carburetor. This idea is confirmed by the fact that the electric fuel pump was pumping far more than usual. Vapor lock never developed, even on high hills in extreme heat. Under ordinary abuse the little car is perfectly willing to deliver around 35 miles per gallon. Driving carefully I made it from New York to Boston on five gallons of "regular." How does forty miles per gallon compare with your Gusho-matic?

As a city car the Morris is excellent. It carries four people in fair comfort, with sufficient space for occasional luggage. It handles easily. It does not accelerate impressively (some 40 seconds from zero to 60), but makes up for it when it comes to parking. Park two cars for the price of one? Just try two Morrises on one meter. I never have, but I have certainly squeezed one into spaces that not even the small domestic cars would fit. The one thing, outside of economy, that makes the Minor an outstanding car is its handling. The rack and pinion steering is both light and positive. With two and one half turns from lock to lock a flick of the wrist will take you around almost any bend. The real surprise comes when this tin can is cornered rapidly. In spite of rather soft springs, roll is slight. The front wheels show great determination to hold the course set for them. Under severe cornering it is possible to get the rear inside wheel off the ground, but good control is maintained. If power is applied on such an occasion the leaf springs "wind up" producing a most disturbing bounce.

Looking under the hood the first impression is one of good accessibility. Everything seems to be easy to reach and simple to work on. The old L-head gave the same impression, but actually gave considerable trouble when adjustments were attempted on carburetor, valves or oil filter. The new overhead valve unit has improved this situation. All around, for what it is, the Morris Minor is a satisfying little machine. Now, let us look at what the German Volkswagen has to offer in competition with the baby carriage from across the Channel.

Since the collapse of Hitler's thousand year Reich, Germany, or rather Western Germany, has made an astonishing economic comeback. Not a small part of this is due to the amazing Volkswagen. Selling in some 80 different countries the Wolfsburg factory has risen to be the world's fourth largest manufacturer of automobiles. Undoubtedly a good part of this is due to efficient management and selling, but let us look at the car itself.

Designed by the automotive genius Dr. Ferdinand Porsche, the V.W. was planned as a people's car. After much redesign by the Doctor's firm the final layout arrived and is one of the most unusual in the automotive industry. The chassis is a simple pressed steel platform. It consists of two flat sections welded to a central tube. This self-carrying platform narrows in front to support two cross tubes mounted one above the other. Two eight-leaf laminated square section torsion bars are built into these tubes. The bars are clamped in the center and terminate in the competition-proved Porsche-type trailing arms. Damping of this suspension is by means of a telescopic oil shock ab-

sorber mounted on a special arm. Steering is through a conventional box and unequal length track rods. At the rear of the chassis the central backbone forks to provide a mounting for the engine. The powerplant itself lies behind the rear wheel centerline, but the gearbox is located forward of the differential, and makes a unit with it. Rear suspension is also independent and by torsion bar, but differs geometrically from the front layout. The wheels are mounted on swinging half axles. Wheel location is achieved by means of a trailing arm. The forward end of this arm is joined to a short circular cross-section torsion-bar, which lies transversely in the frame. As in the front, the bars are fully enclosed, need no maintenance, and are claimed to be indestructible. Hydraulic shocks are also employed in rear axle damping. Now let us focus our attention on the engine.

This unit is specifically designed to harmonize with the rest of the car, and is full of interesting features. It consists of two banks of heavily finned cylinders mounted in opposition. This gives the well-balanced "flat four" arrangement. A single camshaft, located below the crankshaft, operates horizontal overhead valves by means of pushrods and rocker-arms. The cylinder heads are light alloy, and the exhaust valves are of high chrome-nickel steel. A large fan, driven by a V-belt which also powers the generator, cools the engine through a large sheet metal housing. A thermostat located just below the right front cylinder controls a large throttle ring which regulates the flow of cooling air. The fan can handle up to 17.5 cubic feet per second, providing adequate cooling under the most severe conditions. An additional feature is a full pressure oil-cooler enclosed in the cooling shroud. In very cold weather, when the oil is thick, a pressure relief valve bypasses this heat-exchanger to lubricate the engine directly, and provide a faster warm up. The engine is very rugged. A four bearing crankshaft combined with short stroke design permits running "full bore" for indefinite periods. The pistons are aluminum alloy and are equipped with three rings. The connecting-rods carry interchangeable lead bronze bearings. The four main bearings are also light alloy, and the crankshaft running surfaces are heat-treated to give better wear characteristics. Until recently the V.W. engine had a 1131 c.c. (69.014 cu. in.) displacement with a horsepower output of 25 at 3300 r.p.m. This month, however, a new model has become available with an increase in displacement to 1192 c.c. (72.740 cu. in.). With an increase in compression ratio and a redesigned intake manifold the power has been boosted to 30 h.p. at 3400 r.p.m. Surprising though it may seem, a drop in price was announced by the company simultaneously with the increase in power.

The engine is bolted directly to the differential and gearbox casing to form a simple, compact, and reliable power unit. Exhaust gases are individually ducted to a common muffler mounted across the rear of the engine underside. There is an ingenious provision for ducting some of the cooling air across the two front exhaust pipes, through two junction boxes, to the interior of the car. This provides one of the simplest and most effective heating systems available. The volume is controlled from a valve located in such a way between the front seats that anyone in the car can reach it.

Hydraulic brakes and a synchromesh gearbox are virtually standard on the "export" model, but a chromeless, crash-box and mechanical brake model is still available to economy-minded Europeans.

Appearance is, of course, a matter of opinion, but this one takes a little getting used to. It is obviously well streamlined, but its sloping hood and short wheelbase give it a bug-like mien. As soon as you sit in this car the advantage of the low nose is evident. Visibility through the one-piece windshield could hardly be better. On the older model a serious blindspot existed toward the rear, where the window was divided by a thick centerpost. The later model, however, is equipped with a single piece of glass, making the rear view entirely satisfactory. The seats definitely do not have the hip-gripping shape of the Morris Minor's, but are considerably softer. Both front seats are adjustable. If they are pushed all the way back, to accommodate a six foot or taller occupant, there is clearly no leg room left for the rear passengers. Four people can be carried if the need arises, but it is not likely to be in armchair comfort. Behind the rear seat there is a luggage bin capable of holding a good sized trunk. If more capacity is desired the back of the seat tilts forward and makes room for practically anything you can get through the door. Of course, there is some space under the hood. This volume is largely taken up by spare wheel and gas tank, but enough room remains for over-night bags and small equipment. Instrumentation consists of a speedometer, and oil pressure and generator warning lights. The only way to tell how much gas you have is to look in the tank, hardly an enjoyable way of doing things. A valve is provided, however, to permit

The lines of the Volkswagen are uncompromisingly functional.

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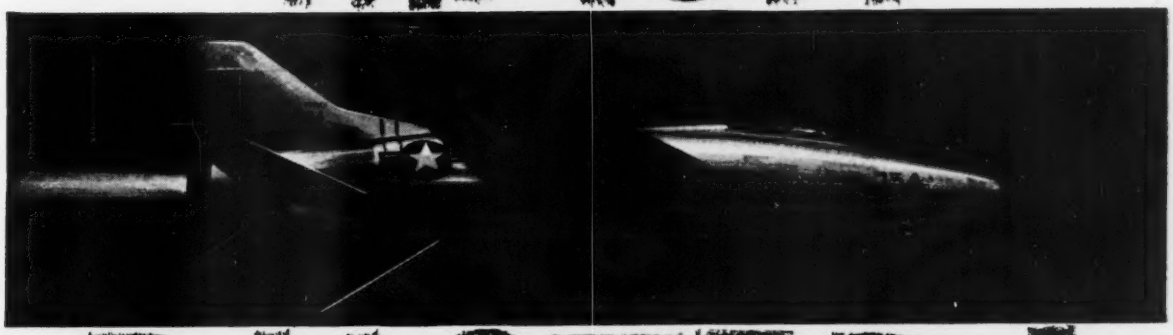

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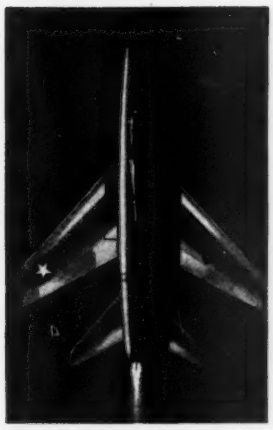

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the use of a reserve gallon or so when the main tank has gone dry.

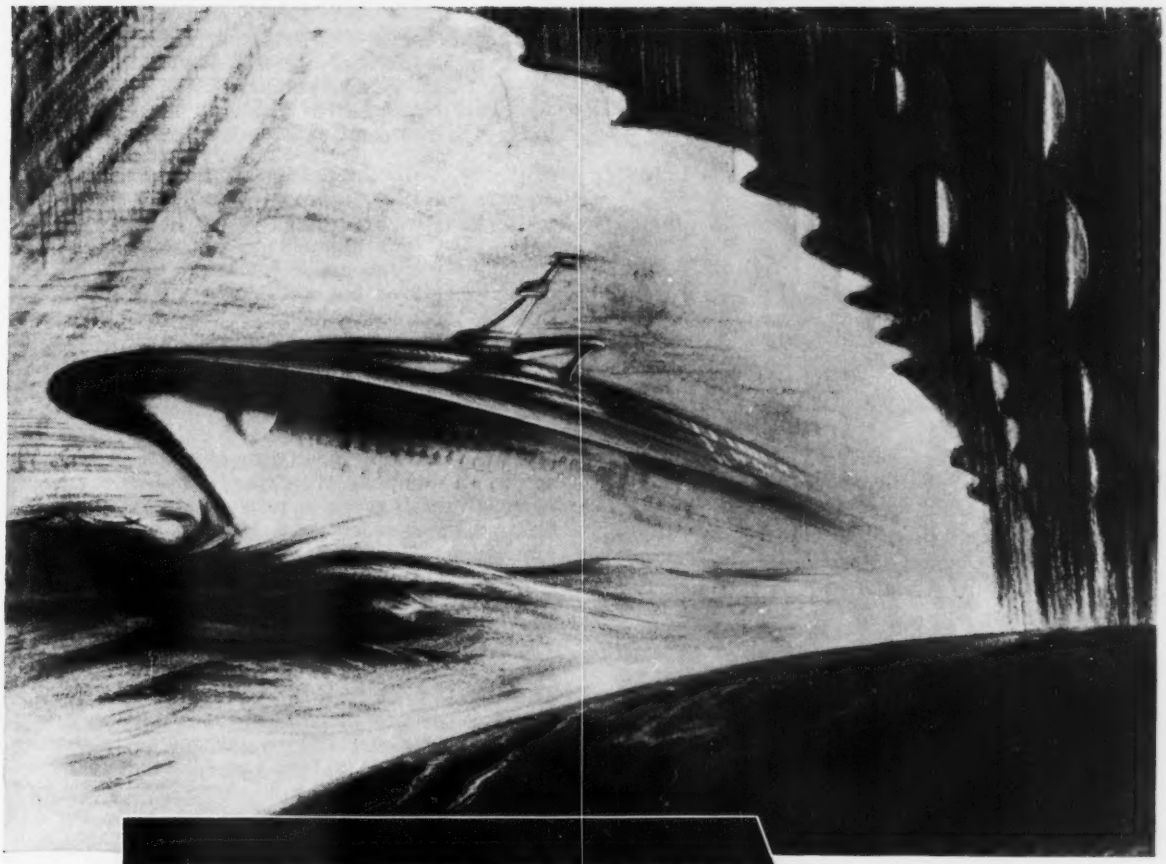
The V.W. starts easily if treated according to factory recommendations. The procedure differs slightly from common practice in that neither accelerator nor clutch should be touched. Full choke is used with a cold engine. For the first-timer with a rear engine the noises coming from behind are a little disturbing. The engine certainly isn't quiet. It sounds like a combination of a distant Greyhound bus and an old Kodak movie projector. After a little traveling around both the quality and the direction of the posterior noises become almost natural. Following well known European practice the hand brake is located between the seats. The gearshift lever protrudes vertically from the central tunnel. Considering that this is a remote control mechanism, the feel of the shift is astonishingly positive. As a safety measure reverse (left and back) cannot be engaged without first pushing the entire lever downward. Three out of the four gears are synchromesh. This mechanism is indeed wonderful. I can honestly say that, outside of the Porsche (which uses the same type of ring synchronizer), I have never driven a smoother functioning gear box. With a low first gear and excellent low speed torque the little car is inclined toward jack-rabbit starts, but acceleration declines fairly soon. It takes roughly 40 seconds from zero to 60 miles per hour.

On the road the little beetle is very interesting. The steering is fast and positive, but not so light as the Morris'. The engine is highly responsive to the throttle, and traffic driving becomes almost a joy. With higher torque than the Morris it can make better use of its good handling characteristics. Its turning circle is somewhat larger than that of the English car, but parking it is still a lot easier than any of Detroit's chrome-carriers. On my first lengthy drive I rapidly gained confidence in the little bug. It took bumps with amazing smoothness (here is where the four wheel independent springing really shows!), and cornered nicely. Inspired by this I casually charged into a 45 degree bend at about the same number of miles per hour. After dropping into third I cut the wheel hard to the left. Suddenly the car decided that the engine belonged in front after all. The rear end showed a strong inclination to pass the front, in spite of screaming protests from the tires. Backing off on the throttle I corrected gently to the right. The V.W. levelled off immediately and came through the corner in fine shape. I soon learned how this German gaspincher has to be handled. It is entirely possible to corner this machine at high speed, but the technique differs some from the conventional approach. The refinement consists mostly of an awareness of the car's oversteering tendencies under brutal cornering. This tendency is compensated for by turning the wheels less than the desired line of action. A perfectly controlled drift can be developed by these methods. Wet weather cornering at speed can be spectacular indeed, especially to those who see the bowlegged little bug disappear around a traffic circle at 40 miles per hour. Under the most extreme cornering the outside rear tire runs on the sidewall, while the other comes off the ground completely. Obviously the V.W. is not intended as a race-car, but rather as reliable family transportation. I have mentioned the extreme only to illustrate the capabilities of the bug. The V.W. can be cornered with the best, but caution is advised when correcting for oversteer. Steering remains sensitive regardless of the car's general attitude and over-correction can easily occur.

While talking about the Morris I mentioned snow conditions. In this department the Morris is good, but the V.W. is even better. With most of the weight concentrated on the driving wheels, this otherwise light car is probably the ideal for snow work. The only other car I have driven that could equal it is the front wheel drive, front engined D.K.W. But to return to the V.W. I remember the consternation of one of my neighbors after a fresh snowfall. It had snowed about four inches. He had dug out a path for his car, but still could not get enough traction to climb to the center of the curved road surface. Casually I wiped the snow off the windshield of the V.W. and gently drove it out of its snowbank. I didn't hear the end of that one for quite some time. The heater, as mentioned before, is very effective. Unfortunately the defroster vents are badly located. I had hoped that the new model would incorporate a change here, but it did not. For continued cold weather operation a fan is necessary to keep the center of the winodw clear.

In hill climbing the Volkswagen is better than the Morris thanks to its low speed torque. Most Bostonians are familiar with "Hospital Hill" off Huntington Avenue. With four up the V.W. climbed it easily in second gear. This was true even of the old version, but the new 30 horsepower job that I drove (courtesy of Foreign Motors, Inc.) should prove to be a veritable pocket sized mountain-goat. The factory reports that the hill-climbing ability has been increased some 30 per cent by the new engine. Weather protection is excellent. This little car is so tight that it is actually difficult to slam the door shut without first opening a window to release the pressure. I have driven it through large puddles at speeds that sprayed water clear to the height of the car, yet not a drop got inside and the engine continued to run as though nothing had happened. It would hardly be wise to try this with a Morris. Long trips with the V.W. are tiring. This is definitely due to the fact that the seats do not give your back the right kind of support. How nice it would be if the qualities of the Morris seats could be combined with those of the V.W.! High average speeds can be maintained due to the aforementioned ability of the engine to run at top speed without undue wear. Mileage is in the vicinity of 32 plus miles per gallon, which is pleasant, to say the least.

The engine is accessible. The carburetor, generator and distributor can be serviced with ease. They are located so that they are in easy reach with the rear deck open. The only problem is presented by the spark plugs. These lie deeply buried in the sides of the engine and are impossible to reach by ordinary means. A special socket wrench with holding clips is provided in the tool kit, which solves the problem nicely. The tool kit is typically German. It includes, in a cloth case, the plug wrench, a set of metric open end wrenches, an adjustable wrench of high quality, a screwdriver,



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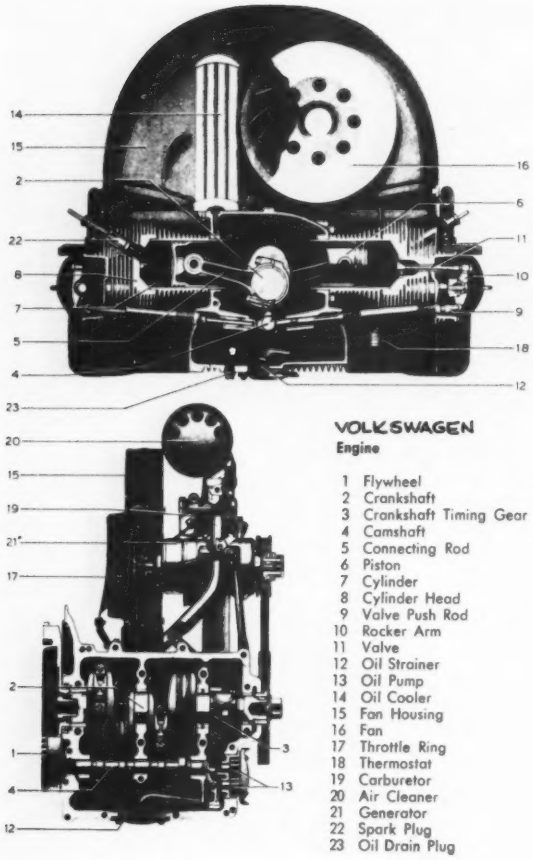

Two small cutaways and chassis view.

and a special wrench for fan belt adjustment. The jack provided is of the bar-climbing type, and is quite ordinary, but its application is interesting. A special hole is built into the side of the car at approximately the line of the center of gravity. The jack is inserted there and lifts the entire side so either end can be worked on.

I have driven both the Morris and Volkswagen for some 10,000 miles, and frankly, I still don't know which I like better. Both have faults, and both have virtues. Where the Morris is easier to handle (although not necessarily better handling), the V.W. has more satisfactory engine performance; there is more legroom in the Morris, but the Volkswagen gives better weather protection; the V.W. is better in traffic, the M.M. easier to park; and so on and so forth. Both are excellent small economy cars, capable of carrying four people and some luggage in reasonable comfort, and the choice remains largely a matter of individual taste. The world market certainly has chosen the V.W.

The third car I want to talk about is quite different from these two, and also the most recently introduced. This is the new one and one half litre M.G. Magnette. Here is a brand new automobile that has just become available in America. One thing that immediately sets the Magnette apart from the other two cars is its price, which exceeds theirs by almost 1,000 dollars. Obviously we can expect this car to be intended as a more luxurious bit of transportation. It is still a small four seater, and therefore can be compared, or rather shown as another approach to a similar problem. Let us look at its technical features.

Like so many other fresh European models, the Magnette has a mono-constructed body and frame. Front suspension is by means of a pair of transverse links. The upper one is of wishbone form, and the lower has an "I" cross-section. The latter is the longer of the two, following the common i.f.s. pattern, and is braced against braking loads by an additional stay. Springing is by coil, with enclosed hydraulic shock absorbers. The shocks are telescopic, and are finned for better heat dissipation. Rack and pinion steering follows the pattern set by the T.D. and T.F. In the rear the suspension appears conventional: semi-elliptics with telescopic oil dampers. Closer examination, however, reveals that there is a torque arm bolted to the differential housing and pivoted approximately amidships. This arm transfers torque reaction during acceleration or braking directly to the frame, thus preventing spring wind-up. Neutral cornering can be expected from this arrangement. From this cursory examination one would predict sportcar cornering, so well associated with M.G. The engine is entirely new, but also quite conventional. It is a new member in the Austin-built family of four-cylinder, in-line, pushrod o.h.v. engines. The displacement is 1489 c.c. (91 cu. in.) with a bore and stroke of 73 x 89 mm (2.875 x 3.5 in.). With dual carburetors and a mild tune the mill puts out 60 horsepower. One can hardly help wondering how this engine would do with a "stage two" tune, installed in the T.F. This might bring the Midget up to a more satisfying performance —but to return to the Magnette . . .

Appearancewise the car has a modern envelope body, with smooth lines, but retaining the traditional M.G. grille. The interior is meant for four people, and no more, and is tastefully appointed in leather. The seats are soft AND formfitting. I found headroom quite limited. When sitting erect in the driver's seat I could detect a distinct pressure on my head. Wearing a hat in this car is fairly well out of the question. The instruments are well located in front of the driver. They include a large speedometer, fuel and temperature gages, and the usual ignition warning light. Again the parking brake is located between the seats. It is not quick-release, but of the conventional spring-hold type. The shift for the four speed and reverse gearbox is floor mounted and feels very positive. It controls the gears through a remote control mechanism very similar to that of the familiar M.G. roadsters. The clutch is conventional dry plate, but actuation is hydraulic. Visibility for the driver is good, and legroom both front and rear is totally satisfactory.

The particular car I drove was furnished by Foreign Motors, Inc. I was warned that this car was the only one in this area, and was not for sale. Moreover, this was a prototype and the rear springs were stiffer than those planned for production. The car was in Boston for exhibition purposes only, and ballast had been placed in the trunk to relieve the high rear end effect. With

this in mind I took the car out for a short test run. The engine is quiet, but performance is nothing overwhelming. The ride is smooth and the steering pleasantly positive. I was most impressed by the gearbox. Even though this car was not broken in the box was easy to manipulate and felt even better than the one on the T.F. Taking the car through some bends I was surprised. From the characteristics of the chassis I had expected sporty handling. This expectation was heightened by the name "Magnette" which brings to memory the performance of the very sporting K-series. I was surprised to find that this new M.G. rolled considerably. The angle of roll is worse than that of any other foreign car I have recently driven. Once this angle of roll is assumed, however, the car corners well. As expected neither over nor understeer are evident. After several corners I stopped and removed the 60-odd pounds of iron from the trunk. The trunk, incidentally, is spacious—an obvious advantage of the new styling.

The M.G. Magnette has adopted the modern idiom without sacrificing the identity of the marque.

With the weight removed the car tended to bounce easily on even slight bumps. In spite of this the cornering characteristics remained unaffected. I am sure that the production model will have softer springs in the hind quarters. This should have a good effect on the ride, but will probably not reduce the roll. Even as it is the ride was good. Acceleration is good up to fifty, and then drops off markedly. As I said, this car was not broken in, and performance was, of course, restricted. Under gentle but firm treatment I got stopwatch versus speedometer figures of 20 seconds zero to 50, and 27.5 seconds zero to 60. All this is terribly approximate. After the run I opened the hood to check for accessibility. The grille is integral with the alligator type hood—a practice that seems to be spreading in Europe (Mercedes, Riley). The Austin derivation of the engine is disguised by the twin S.U. carburation setup. Accessibility is good, as there is considerable room in the envelope body. The battery and toolbox flank the heater motor on the firewall.

Summing up, the Magnette has few of the characteristics of its snarling little namesake. This M.G. is distinctly the Englishman's idea of a medium priced family car. It rides comfortably, has luxurious interior appointments, handles easily, and gives fair engine performance. This car should hold considerable appeal for the man who wants high comfort in a small car, and doesn't care much for dragging and drifting.

INCIDENTAL INTELLIGENCE

There are a number of interesting and relatively little-known situations that are developing in the sports car and racing fields that I would like to bring to your attention. First, and perhaps most interesting is the fact that a Ferrari entry in this year's Indianapolis 500 mile race seems a certainty, barring the emergence of last-minute technical troubles. Even these are not likely, as the car (there is to be only one) is presently in this country, and was, indeed, exhibited at the recent International Motor Sports Show in New York City. The Ferrari organization at first endeavored to have the car ready for last year's race, but when this was seen to be impossible they abandoned last-minute efforts and continued development for another year. The entry is being sponsored by a group of American Ferrari enthusiasts, among whom are Jim Kimberly, Ed Lunken, and Bill Spear. Alberto Ascari could not be engaged as driver, since he has severed relations with the Ferrari organization, and the group has tentatively engaged Luigi Villoresi for the job. This is a particularly good choice, as Villoresi has driven at Indianapolis before with the old Maserati team, and is a strong and steady competitor.

The car itself is of particular interest, in that it has been tailored to the peculiar requirements of the Indiana oval. The powerplant is the familiar four and one half liter V-twelve, which was designed for European road racing where power in the middle speed ranges can be sacrificed for advances at high r.p.m. This engine, however, has been specially tuned to give particularly good torque at the speeds that will be used when accelerating out of the four right-angle bends. The chassis is also of Formula I derivation, with De Dion tube passing to the rear of the combined final-drive unit and gearbox. The shock absorbers and spring rates are adjusted to compensate for the weight shift on the left hand bends, as was indicated by the mark "IND." on each damper arm. The body form is the pregnant shape recently adopted for the smaller unblown Grand Prix cars, but gasoline is stored in only the left hand instead of in both the bulging side enclosures. The right hand excrescence is merely a housing for an oil cooling radiator. Wire wheels are again used, but with three-eared Rudge nuts and a particularly sturdy spoke arrangement. On the whole, it looks like an intelligent and concentrated effort to build the car to fit the track, and Lampredi and the other Ferrari engineers are to be congratulated on the use they made of their experience of two years ago. It is difficult to evaluate the possible performance of such a car, but it is running against almost impossible odds. Kurtis-Kraft chassis and

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a geometrical consideration of fermat's theorem

by A. B. Harper, Jr., '54

About one hundred and one years ago, a French mathematician wrote in one of his books, "To divide a cube into two other cubes, a fourth power, or in general any power whatever into two powers of the same denomination above the second is impossible, and I have assuredly found an admirable proof of this, but the margin is too small to contain it." And for one hundred and one years this theorem of Fermat's has not been proved for the general case. The equation is usually set up as $a^n+b^n=c^n$. The assumptions usually associated are: a, b, c, are non-zero integers, and that a, b, c, have no common factors (as these could be canceled). It is easy to show, using the initial assumptions that a cannot be equal to b. If this were the case, we could write the equation as $2a^n=c^n$. This implies that c^n is even and therefore c must be even. We could express c as $2c_1$; making this substitution the equation becomes $a^n=2^{n-1}\ c_1^n$. This equation, however implies that a is even which contradicts the assumption that a and c had no common factors. We also make the observation that the pairs (a,b), (b,c), (a,c) must also be relatively prime. Suppose that a and c had the common factor d, then the equation could be written as $b^n=d^n\ (c_1^n-a_1^n)$, which implies that b also has the factor d, and this again contradicts the secondary assumption. Consider the substitution $x=a/c$, $y=b/c$. The restrictions on x and y are now: x, y are rational, x is not equal to y, neither x nor y are 1 or 0. If we look at the special case of n being even, we may plot the equation $x^n+y^n=1$ on a Cartesian system. The minimum permissible value on n is 4, this plot (Fig. 1) appears as a square with rounded corners. As n becomes large the plot of the equation approaches the unit square (Fig. 1). Also on Figure 1 are the lines x=y and

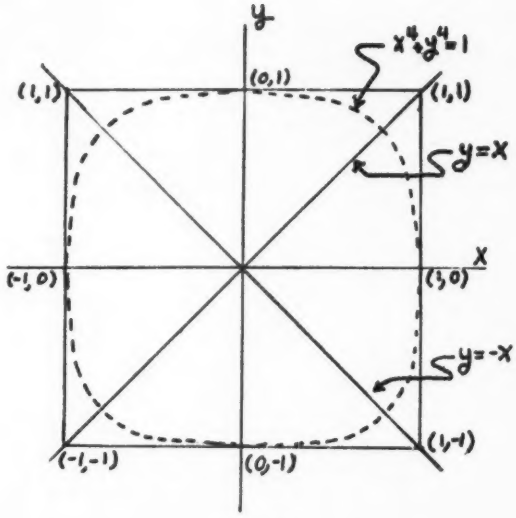


Fig. 1

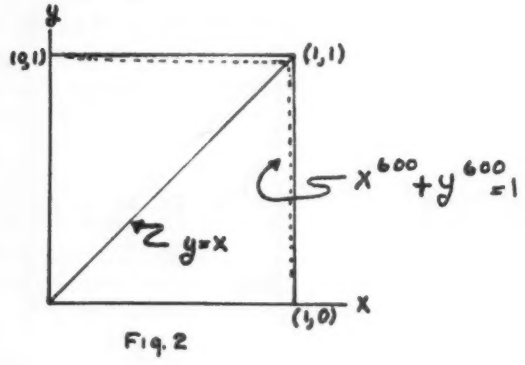


Fig. 2

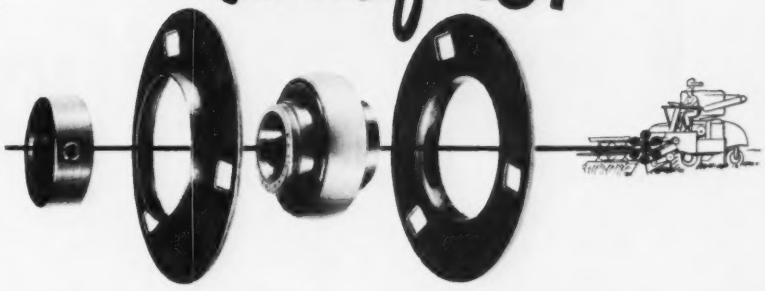
x= —y. The solutions to the problem, if they exist, must fall into the eight areas outside or on the plot for n equal to 4, inside the unit square and not on the lines x equals y, or x equals minus y. Because we assumed that n is even, we may only consider those solutions which lie in the first quadrant. In addition we note that the line y equals x is a line of symmetry with respect to the first quadrant so that we may consider solutions with either y greater than x or the reverse.

Up to the present time, it has been shown that the theorem of Fermat is true for all n up to about six hundred. Using these results we can gain some interesting information on x and y. The question to consider is what powers of other rational numbers could x and y be simultaneously. For example could x and y be, simultaneously, sixth powers of two other rational numbers? This is impossible, for if $x=x^6$ and $y=y^6$ this would imply that $x^{12}+y^{12}=1$, as we can find an x and y such that $x^2+y^2=1$, but it has been shown that no solution exists for n equal to twelve, thus x and y cannot be sixth powers of other rational numbers. Using this method it is easy to show that for many n over six hundred no solution exists. It was originally assumed that n was even, but for this argument that restriction may be temporarily removed. If n is expressible as n_1n_2 where n_1 is less than six hundred then no solution will exist for n_1n_2 for any value of n_2 such that the product of n_1 and n_2 is greater than or equal to three. It is obvious that we must restrict n_1 to be greater than or equal to three also. This method does not, of course, cover all the numbers above six hundred. Two classes of

numbers are omitted, those which are prime (above 600) and those numbers which are double any prime (above 600). In considering x and y we assume that they are greater than zero, but when considering a, b, and c this is not necessary.

In Figure 2 there is a plot of the equation $x^{600}+y^{600}=1$, this is plotted in the first quadrant only. The restriction of even n is again put on. The unit square is also drawn in as the upper bound on solutions. If we now consider the area for which x is greater than y (in the lower right), the intersection of the plot with n equal to 600 and the line x equals y, gives the restriction on x. This restriction is that x must be greater than 0.998. We make the observation that the solutions are now restricted to a very small area. We may now use some of the results previously derived. The only values of n for which solutions may exist are, if n is a prime above six hundred or if x is double a prime, again above six hundred. For special cases of x we may also show that no solution will exist for all n greater than some determined n_o. Consider x expressed as a sequence of nines, say r of them, then we may write x as $1-10^{-r}$. If we can determine some n_o such that X^{n_o} is less than 0.5, then no solution will exist for all n greater than or equal to n_o in the area x greater than y. This is easily done by solving the equation $(1-10^{-r})^{n_o} < 0.5$. If we expand out the left side and set the first three terms equal to 0.5 and solve the resulting quadratic equation for n_o, we find $n_o=10^r+0.5+0.5\ (4.\times 10^r-1)^{1/2}$. This may be appraised to give an integral value of n_o equal to 10^r+1 plus the next larger odd number of $10^{r/2}$. By the initial restriction n_o must be even. Many other attacks have been made on this problem but as yet only for special cases has the proof been forthcoming. Fermat used many subtle tricks in his proofs, and perhaps one of them will some time be used in this proof. It is my personal opinion that, if the theorem can be proved, it may not be done by someone skilled in mathematics but rather by what I will call an "astute dabbler in mathematics".

The idea that caught like *Wildfire!*



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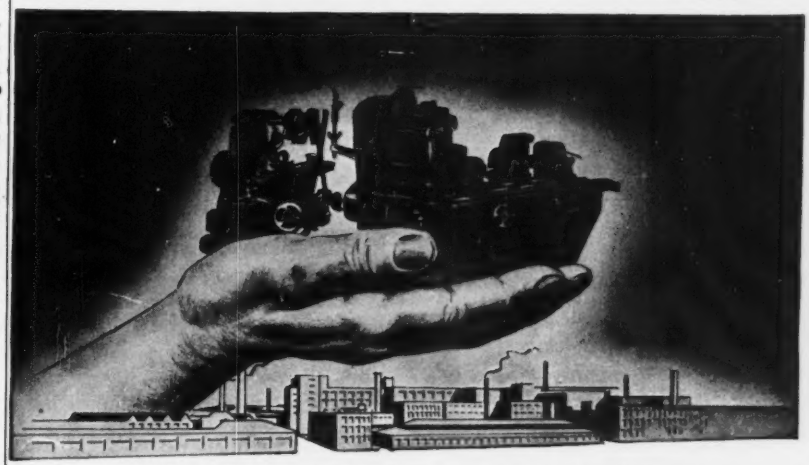

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Cable specifications and

THE POSSIBILITY of fires and personal injury connected with distribution of electricity by means of wires and cables, means that such wires must conform to certain minimum requirements. This was recognized in 1881 by New York's Board of Fire Underwriters, when it outlawed the use of bare or uncovered wires for the distribution of electricity in buildings and adopted "A standard for Electric Light Wires, Lamps, etc." This standard contained five rules, one for the conductivity of the conductor, one describing the insulation and the other three dealing with installation of electrical equipment. The rules for the conductor and insulation read as follows:

"1. Wires to have 50 percent excess conductivity above the amount calculated as necessary for the number of lights to be supplied by the wire.

"2. Wires to be thoroughly insulated and doubly coated with some insulating material." These two rules constitute the first effort to set up limits or to be specific with regard to insulated wire for power distribution. In other words, they constitute the first specification for insulated wires and cables for the distribution of electricity.

Historically, the next important concept concerning the covering was that of its insulating properties or its ability to confine the potential to the conductor. This was established by setting up minimum thickness of the insulation for the various conductor sizes and providing requirements for test voltages and insulation resistances for these thicknesses. Such requirements were included for the first time in the National Electrical Code for 1899. The insulation thickness for rubber insulation for a given voltage service and conductor size was essentially the same as that used today, namely, 3/64" on size 14 Awg. for 600 volt cable. The test voltage requirement was 3000 volts per 1/64" of insulation thickness, after immersion in water, distinctly more severe than present requirements. The insulation resistance requirement for 600 volt wire was 100 megohms per mile. The 1899 code also contained requirements for the dimensions of copper conductors and for tinning of conductors for rubber insulated cables. There appeared here, for the first time, a requirement for braids.

This was followed by the establishment of minimum requirements for tensile strength and elongation of rubber insulations in the original specification of the Association of American Railroads in 1905 and Underwriters' Laboratories, Inc. Standard about 1911. The 1905 specification of A.A.R. also included requirements for the chemical composition of thirty percent rubber insulation. These requirements were later adopted by Underwriters' Laboratories, Inc. and the American Society for Testing Materials.

Although aging requirements for rubber insulation were proposed in connection with the first specification of the Association of American Railroads, it was not until 1933 issue of Specification D 27 of the American Society of Testing Materials that aging became an industry specification requirement for rubber insulations. The requirements for heat-resisting rubber were included for the first time in A.S.T.M. specifications for 1937. The requirements for moisture resisting rubber insulation were established about this time. The requirements for Polyvinyl Chloride and Laytex insulations were established in the National Electrical Code of 1940. Since then the requirements for the various synthetic rubber insulations have been set up.

During this period, other types of insulations such as paper, varnished cambric and asbestos and many types of sheaths and coverings for wires and cables were developed. More detailed requirements for conductors were also established. There are today, therefore, a wide variety of cables for use in the distribution of electricity for power and control purposes.

Practically every element of these wires and cables is covered by detailed specification requirements or standards. There are specifications for bare or uninsulated wires and cables, for covered wires, such as weatherproof wire and all insulated wires and cables, regardless of the type of insulation or coverings. Such specifications cover, in detail, the construction and requirements for the conductor, the thickness, physical, aging, electrical, moisture

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UNITED STATES RUBBER COMPANY

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standards

and ozone resisting properties of the insulation, the construction details of the cables and the thickness and other properties of the covering or sheath. These specifications are issued by literally hundreds of manufacturing organizations, municipalities, railroads, utilities, government agencies, etc. They may differ only slightly but significantly, in certain details, thus making it necessary to run many wires on special orders. The wire and cable industry is thus obviously specification conscious. In fact, it is probably true that all types of wires and cables used today are more completely covered by specifications than any other class of commercial products of equal complexity.

Specifications have thus become a necessary and important part of the wire and cable industry. When properly prepared on the basis of sound engineering, information and manufacturing practices, they provide for durable, economical and safe cables for any particular application. They describe the item in a clear and concise manner that can be readily understood by any one familiar with the industry. They form the basis for contracts between cable users and cable manufacturers, and eliminate or minimize any questions that might arise concerning the construction or quality of the cable under consideration. A working knowledge of wire and cable specifications is essential for those interested in the development, manufacture and use of wires and cables.

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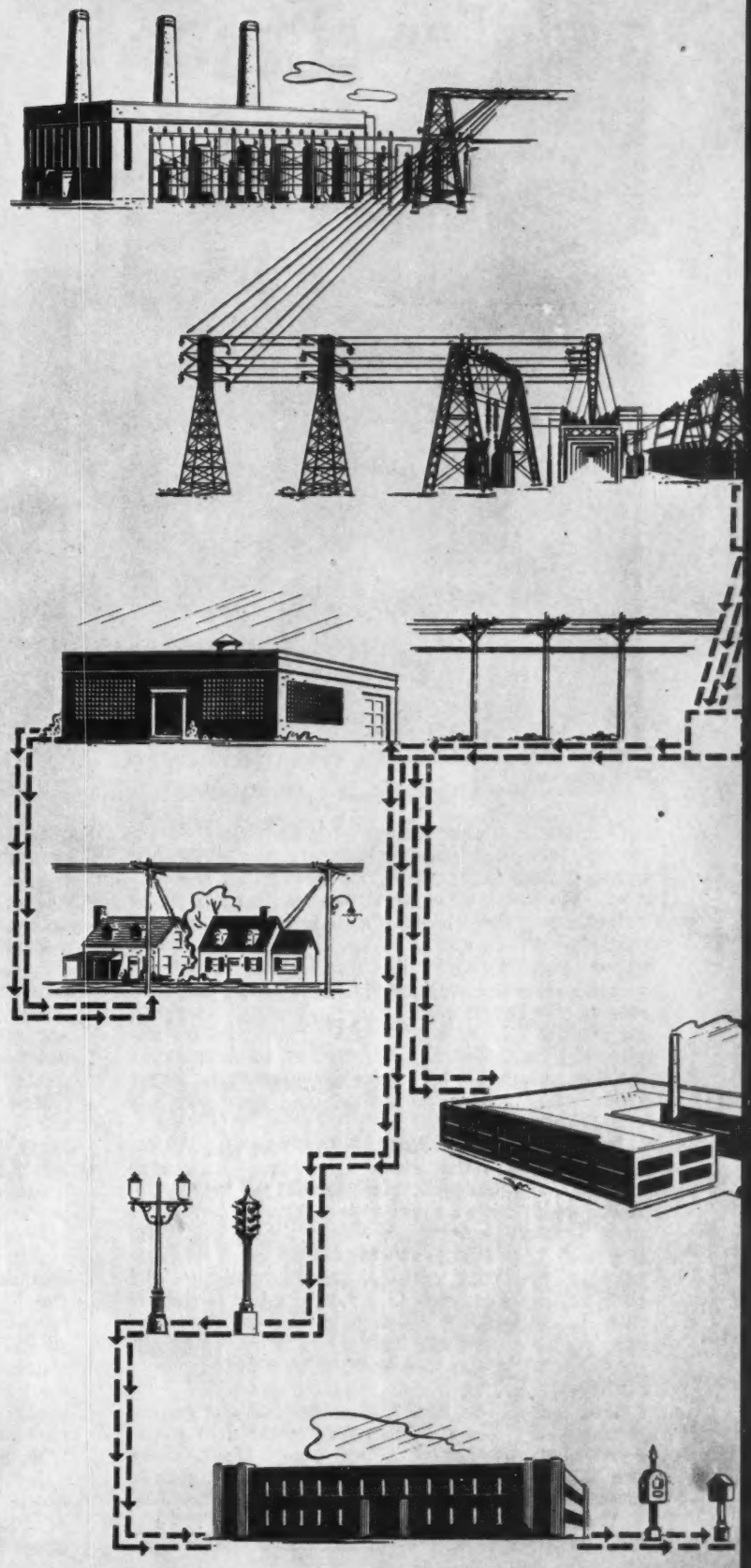


exploding stars

by Robert L. White, '55

Figure 1. It can be seen that the shell for Nova Persei was not spherical.

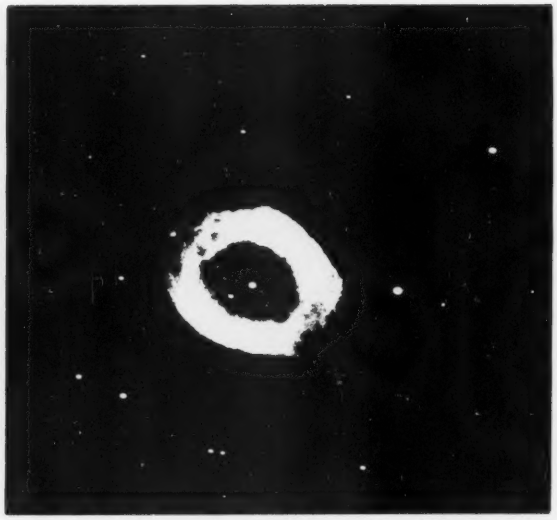


Figure 2. A photograph of the famous Ring Nebula in the constellation of Lyra taken at the Mount Wilson Observatory.

Will our sun blow up one of these days? It is a known fact that stars, which are also suns, are blowing their tops every day throughout the universe. However, we need not worry too much since astronomers feel that our sun is not the type of star that carries on in this manner. Yet, if our sun should ever flip its lid like one of these stars, we would cease to exist. Within one half hour, the side of the Earth facing the sun would be a crisp. Before the Earth could rotate on its axis to complete the day, the night side would be devastated by live steam. A few days later, metalic vapor from the sun would have vaporized what was left of the Earth.

Whenever a star blows its top we call it nova, which means a new star. This name originated before the invention of the telescope. Today, we know that the star existed before it became a nova and, consequently, we cannot technically call it a new star. Novae are stars that rise from comparative obscurity with remarkable rapidity, and then gradually subside to something like their former faintness. Only seven have become conspicuous to the naked eye in this century, although many occur in our own galaxy (the Milky Way) each year.

Undoubtedly most of you know that our galaxy is something like a huge rotating cloud of stars, containing about one hundred billion stars. There are billions of other galaxies comparable in size to ours.

The exact reason why a star becomes a nova is not understood very well. Most astronomers believe that it is due to an upset in the equilibrium between the weight of the overlying material and the pressure of the gas and radiation within the star. This condition is somewhat analogous to a safety valve. Whenever the pressure builds up to a sizable value at some location within a star, an escape valve at some location must be available so that this excess energy might be partially dispersed outside of the star. If this escape valve is not present, the pressure continues building up until an enormous explosion occurs. This is accompanied by the ejection of an expanding atmospheric shell. Sometimes there are a number of these shells expanding with different velocities from the same star. Velocities of 1000 kilometers per second are not uncommon. In some cases these shells are not perfectly spherical, (indicating) that the explosion had occurred on just one side of the star.

After a number of days, months, or years, the star shrinks back to about its original size. Yet, the light that we receive from the star is still large because of reflection from the atmospheric shells which are still expanding into interstellar space. These shells possess a cloud-like appearance and are usually called nebulae. Whenever we find a star in the sky which is surrounded by such a cloud, we call it a planetary nebula, although there is nothing pertaining to planets about the object.

Novae usually attain an absolute brightness of about 25,000 times that of the sun. Yet, the nearest recorded novae have been found to be at such a great distance from the sun that they appear only

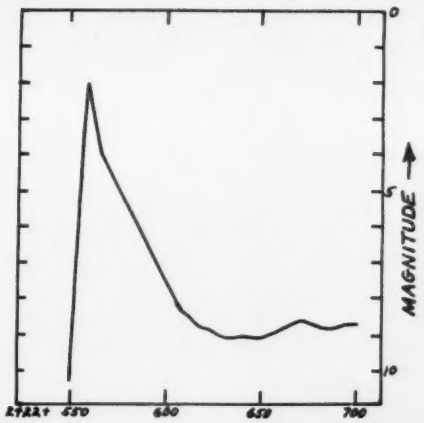
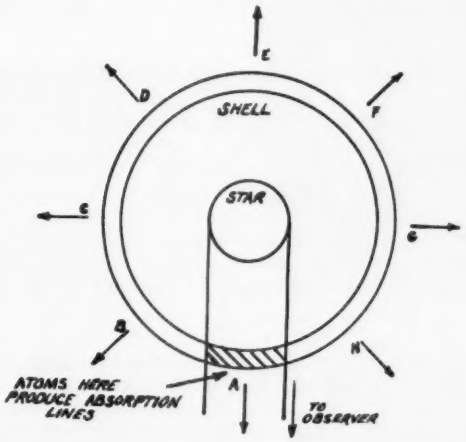


Figure 3. The light curve of a typical nova. Notice the sharp rise in luminosity at the left and then the slow decline.

Figure 4. The Doppler Effect is the principle by which the rate of expansion of an atmospheric shell is obtained. The light from this expanding shell is picked up by a telescope and sent through a spectroscope; the displacement of the lines in the spectrum indicate the apparent speed of the gas producing these lines. In figure 4 the arrows indicate the directions of motion of the various parts of the shell. The crosshatched portion represents that part of the shell that is between the star and the observer. The atoms in this portion have a tendency to absorb certain frequencies of the radiation given off by the star. Consequently, we do not receive any radiation at these frequencies. In their place we have dark lines in the spectrum which denote an absence of radiation at these frequencies. The dark lines are displaced toward the violet end of the spectrum because of the motion of these atoms towards us.

The atoms in the remaining portion of the shell happen to be re-radiating some of the radiation from the star at certain frequencies and, consequently, we receive bright lines on the spectrum for that portion of the expanding shell. Regions B and H are moving towards the observer, thus causing a shift towards the violet end of the spectrum. At C and G, the material is moving at right angles to the observer and no Doppler Effect is present. At D and F, the material is moving away from the observer and the result is a shift of the bright lines towards the red end.



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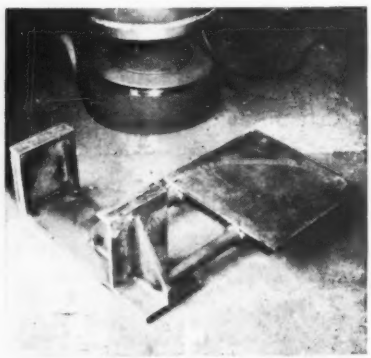

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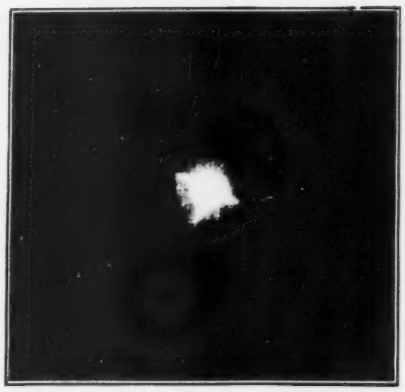

as bright as our brightest stars. The brightest nova on record appeared in 1572. This star attained a brightness equal to that of the planet Venus, which is sometimes called the evening or morning star. Venus sometimes becomes brighter than any of the stars or the other planets. None of the bright novae that have occurred in this century have ever become as bright as Sirius, which is the brightest star in the sky.

At present it seems that novae originate from dense white or blue stars. Usually their color is blue, which indicates that they are among the hottest stars in the universe. Our sun is yellow and, consequently, does not have as high a temperature. It is for this reason that we feel that our sun is not afflicted with this nova-itis. Theoretical studies indicate that a delicate equilibrium is present in these dense white and blue stars. In general, it is believed that novae repeat themselves in periods of millions of years. Yet, some have been known to explode two or three times within a few years.

At this point it might be advantageous to point to a type of nova which would put to shame those that have been discussed up to now. By this I mean a supernova. The first of these that was seen was in 1885 near the center of the Andromeda Nebula. The nova attained a brilliancy equal to about a tenth the luminosity of that whole galaxy, which is saying a good deal, because this galaxy is now believed to be little larger than our own. The spectrum of this nova was not like that of any ordinary novae. In 1917, photographs were taken of other novae in the Andromeda Nebula but these objects were thousands of times fainter than that of the 1885 nova. This made it a certainty that the 1885 object was no regular run-of-the-mill nova.

Since 1885, a number of supernovae have been observed in more distant galaxies. In one galaxy, three appeared within a period of 16 years. It has been estimated by Zwicky that on the average the flare-up of a supernova is likely to occur in each galaxy once every 600 years. Some of these novae have become a hundred times brighter than the galaxy in which they were located. One is known to have attained a brilliancy of about 600 million suns. This is really "blowing your top off" on a prodigious scale. To radiate this much light, a supernova must swell up to gigantic proportions, probably many times larger than the orbit of the Earth. The velocity of ejection of the atmospheric shells is believed to be at least 5000 kilometers per second as compared to a few hundred kilometers per second for ordinary novae.

Two or perhaps three supernovae have possibly been observed in our own galaxy. In 1572, a nova was observed that outshone Venus and was easily visible in full daylight. It is believed that the star observed by Kepler in 1604 was also a supernova. The Crab Nebula, a slowly expanding cloud of gas located about 5000 light years from us, is also believed to be the results of a supernova. Measurements made on this expanding cloud of gas indicate that the expansion started from a single origin approximately 900 years ago. This date is important, because an anonymous Chinese astronomer noted a bright star in the same part of the sky in the year 1054.

The origin of supernovae is still somewhat obscure. One of the best suggestions put forth to explain this stupendous explosion is that made by Whipple. He believes that a supernova is the result of a collision between two stars. Such an impact would result in a catastrophe, and that is exactly what a supernova is.

Another page for **YOUR BEARING NOTEBOOK**

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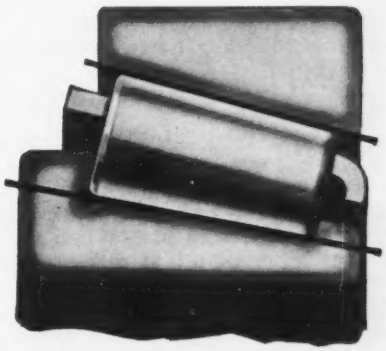

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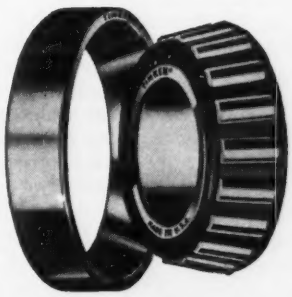

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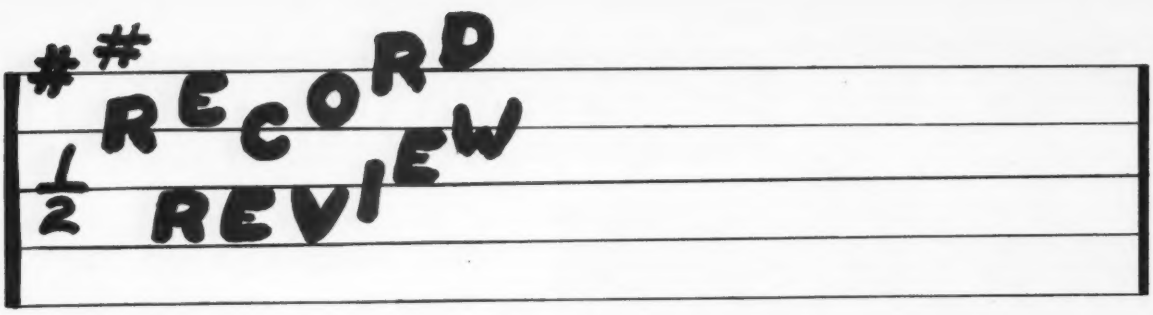

by Dave Klepper, G.

For this review the Editor has asked me to forget my usual procedure of reporting one or more recordings of a single work to discuss recording companies and their products in general.

Before discussing record manufacturers' work it is only fair to tell you what my reproducing equipment is and how I operate it; you may then determine whether my remarks have any meaning for you. I use a broadcast model GE pickup in a Grey standard arm, with a G. I. turntable. The arm of the stylus assembly was filed down while undergoing comparison with a Fairchild cartridge, and the sound, not at all bad to begin with, has been improved. The signal is fed to a McIntosh preamplifier, modified. This offers a choice of 300, 400, 500, and 800 cycle turnover, while the single treble control has been calibrated for AES (12 db down at 10 KC) and NAB-COL (16 db down) curves. The bass control is used to differentiate between the NAB and COL curves, both of which use 500 cps turnover. A noise supressor is used when necessary, and a TechMaster Williamson feeds a Western Electric monitoring speaker (8") mounted as per instructions. I attend concerts fairly regularly and think I know what an orchestra or chamber group should sound like. When my ear tells me a setting other than that corresponding to the recording curve of the manufacturer is called for I'll believe my ear.

We'll discuss RCA's work first. Victor was once IT in the phonograph industry; now they still don't seem to know exactly what kind of sound they want on phonograph records. We have heard RCA recordings that are so unnaturally resonant that the detail of the music is lost and obscured, e.g., Schuman's First Symphony; but much of their most recent work features dry, deadened sound, the kind that makes so many Toscanini recordings a disappointment to people who know and love the sound of a symphony orchestra performing in a good hall. Best example of this is the new *Missa Solimnis* recording, a work written to be performed in that most resonant type of environment, a Catholic church. The recording has other faults, the tenor sounds as if he's at the sending end of a trans-Atlantic short wave broadcast, but the dominating characteristic of the recording is its deadness. The culprit is probably the new highly directional mike which RCA says, on the notes with the album, to be the ultimate in high fidelity. (For those that care to know the album remains indispensable to me because of its wonderful musical content.) Really fine surfaces, far superior to the competition, do not redeem the sound of a majority of RCA releases; high fidelity publicity to the contrary, RCA still has not gotten over the practice of peaking the middle "highs" as a substitute for real brilliance on recordings.

There are exceptions. Many of the best HMV import rereleases contain wonderful sound. So do a lot of Boston Symphony recordings. Strangely enough, many of the earliest RCA thirty-threes have the best sound, if one is willing to boost the bass a lot and fiddle around with the treble to compensate for the queer recording curve RCA used before 1952. The Monteux recording of Symphony Fantastique may represent what RCA's West Coast engineers could do when they forgot about the kind of sound the New York and Camden offices believed phonographs should reproduce! Some LCTs are decent also!

RCA's "New Orthophonic" recording curve has been discovered as best by the industry and will soon be adopted by the industry. It's the NAB bass curve with a treble only slightly different from AES.

Columbia's biggest fault is horrible surfaces. The records are now being manufactured with a profusion of built in clicks and thuds that distract even the most earnest music lover, and that win complete victory over the best noise suppressors and filters. Other than that, their latest recordings are excellent. Columbia built up its LP catalogue in a great hurry, so some of the early releases were bound to contain distortion and a limited frequency response. Many of the early LP's still sound surprisingly good, however; and now Columbia has reached what is for me the ideal balance between resonance, or fullness of sound, and clarity. The orchestral sound seem perfectly natural, brilliant, but with no trick. Special mention is called for the bulk of this company's chamber music recordings, presenting quartets, etc., in an environment closely approximating a rather large living room or salon. Comparison of the more recent Budapest recordings (Mozart Quartets) with earlier ones (Beethoven Quartets) indicate Columbia is moving from its old recording curve to the new RCA curve; less treble cut (or more treble) is necessary to make the recordings sound right. Here is a good place to mention that a few perfectly fine LP's, including many of Columbia and RCA, that were rereleased from seventy-eights, and not all of them say so, have not been re-equalized in the rerecording process. They demand a low turnover frequency (250-300 cps) if they are not to sound "boomy"; treble sounds lacking unless it is played flat.

London was the original firm to make any claims to "hi-fi" sound with the FFRR slogan. The recordings have generally sounded fine to me, although some early ones and rereleases from

(Continued on page 50)

Brig. General David Sarnoff, Chairman of the Board, Radio Corporation of America

Sees No. 1 wish come true!

Television Tape Recording by RCA Opens New Era of Electronic Photography

In 1956, RCA's General Sarnoff will celebrate his 50th year in the field of radio. Looking ahead to that occasion, three years ago, he asked his family of scientists and researchers for three gifts to mark that anniversary: (1) A television tape recorder, (2) An electronic air conditioner, (3) A true amplifier of light.

Gift No. 1—the video tape recorder—has already been successfully demonstrated, two years ahead of time! Both color and black-and-white TV pictures were instantly recorded without any photographic development or processing.

You can imagine the future importance of this development to television broadcasting, to motion pictures, education, industry and national defense. And you can see its entertainment value to you, in your own home. There the tape equipment could be used for home movies, and—by connecting it to your television set—you could make personal recordings of your favorite TV programs.

Expressing his gratitude for this "gift," Gen. Sarnoff said it was only a matter of time, perhaps two years, before the finishing touches would bring this recording system to commercial reality. He described it as the first major step into an era of "electronic photography."

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RADIO CORPORATION OF AMERICA

World leader in radio—first in television

russian inventions

by John A. Decker, '57

The Russians, if one could believe the Soviet press releases, are an amazingly inventive and productive people—and one that knows how to keep a secret! A majority, if not all, of the world's greatest scientists have lived in the Soviet Union, one discovers, although few outside Russia have heard of many of these "greats."

Not only does Russia seem to have a world monopoly on scientific personnel, but to its inventive genius goes the majority of the world's great discoveries and inventions! The most amazing part of this whole picture, though, is the fact that most of these great Russian discoveries didn't come to light until well after the advent of the current Twentieth Century cold war! This, of course, is explained by the Soviets in terms of "the cruel capitalists from Western nations stealing inventions and discoveries from a bungling Tzarist government."

All this is gathered from a quick glance at recent Soviet periodicals and a short dip into the fantasies of the Russian state radio. The true facts of this double-identity case in scientific progress are rather hard to acquire, because of the tensions of the world situation and the resulting waves of propaganda and counter-propaganda. There are reasons on both sides why this or that specific claim should or should not be discounted, but this gets rather complex. Before we fall into this abyss of historical rationale and counter-rationale, I think it would be best to take a quick look at some of the Russian claims, both past and present.

The Russian scientists seem to have done some of their most productive work in the field of aviation, having invented the first airplane and several modern innovations, such as jet-propulsion and the helicopter. According to Soviet books, the air age opened on one bright day in 1883 when the Russian inventor Mozhaisky made the first flight in his wood-and-wire monoplane. This preceded the Wright Brothers' flight of 1903 by twenty years—although some modern aeronautical engineers have stated that they consider the Russian plane definitely *not* capable of flight!

The Russian's first contribution to aviation, however, was the helicopter, which Russians credit to an unknown inventor of the Eighteenth Century —a claim which the West can challenge by Leonardo da Vinci's Sixteenth Century plans for a rotary-wing aircraft. The Russians also claim to have made the first successful jet-powered flight in the early 1940's—a flight the Western world usually ascribes to Fritz von Opal of Germany in 1929. This same flight by von Opal also refutes the Soviet's claim that the Russian inventor, Tsiolkovsky, was the first man to successfully use rocket propulsion for powered flight.

The Red aeronautical engineers were no more valiant in the Soviet cause than were the Russian aviators, foremost of whom was Nagursky, who made—according to the Soviet Press—the first North Pole flight in 1914, an honor usually given to Byrd and Bennett of the United States with their flight in 1926.

The Russian explorers, however, did not always work for the best interests of the homeland as is evidenced by their discovery of the continent of America, the modern-day citadel of decadent capitalism. This feat, the end result of which must lie heavy indeed upon the conscience of the 20th Century Communist, is usually laid by Western historians to Christopher Columbus in 1492 or to Lief Erikson at about 1000 A.D.

In the field of electronics the Russian scientists were lead by the brilliant genius of Alexander Popov, the inventor — in Soviet eyes — of radio ("stolen" from him by Marconi in 1895), radar (stolen by British and American engineers in 1922, 25 years after his discovery of its principles), and radio navigation! Following Popov's lead, other Soviet scientists are alleged to have perfected television — long before V. K. Zworykin's United States Patent on it in 1928.

The telegraph is also a Soviet invention, having been developed by Z. Y. Slonimsky—from whom Morse, Stearnes, and Edison swiped their ideas. The electric motor, invented in the early 1800's by Joukovsky, is also a point of friction between the East and the West. The West, sticking to its slow, decadent, and capitalistic — but factual — history books, claim that a Nineteenth Century French scientist, Michael Faraday, was the true developer of this engine—a view Russia doesn't seem to share! The Edison lamp—developed by the Russian engineer Ladyguine in 1873—is another conquest of Soviet science over nature; not, as is usually thought among we enslaved masses in the United States, a conquest of American engineering know how—in the personality of Thomas Edison in 1879.

The historic launching (and sinking!) of designer Nikonov's strange craft in 1724 was the beginning of the modern submarine. The first Western submarine lagged almost a hundred years behind this original Soviet development, coming as a crude sub designed by Drebble of Holland. The paddle-wheel boat is also claimed by the Soviet, the brain-child of Kourikine in 1804—not of Fitch in 1786 as most Americans believe. This appears to be a case where the "dirty American capitalists" had to jump into the fourth dimension to steal the "people's invention." Not a bad trick! This same paddle-boat holds the Soviet title for being the first steamboat, in which it beats out the West's contender for the honor, Robert Fulton's *Clermont* by about five years—in the positive direction this time!

Delving still deeper into the mysteries of Russian mechanics, the Soviet designer Polzunov invented the steam locomotive, his coming into view considerably before Stephenson's 1814 model. The tractor also seems to be a product of the unbeatable Russian inventive talent, as it was designed by Blinov in the 1850's, along with the caterpillar tractor and the combine.

The internal combustion engine itself—the basis for the modern aircraft and automotive industries —was developed by a Russian instead of Lenoir of France as is commonly thought. Even more basic in the field of power, a Soviet engineer, Polzounov,

developed the steam engine in the early 1800's—leaving Watt and his 1769 model engine definitely dangling somewhere just off the space-time curve! (Again this happens! Either the Soviets have perfected time-travel or else someone will be getting an all-expenses paid trip to Siberia!) As a further help to modern industry, the Russian inventor Andre Nortov developed the machine tool—without which the production line would be impossible—early in the 1700's—not waiting for Modsly's design in the early 1800's.

In a great service to future science, the Russian Anosov perfected the microscope in 1832—undoubtedly basing his work on the earlier developments of Westerners Jansson (who worked around 1590), Newton, and Galilieo! Kouzminski beat Sir C. A. Parsons of Great Britain by eighty years in the development of the steam turbine, and Vassilil Lindenwald completed his work on ball bearings in 1838—a world scoop on the subject!

Again in the aerial realm, the pilot who first dared to pull a plane through a loop successfully was the Soviet aviator Nestorov, who performed the feat in 1915. The first balloon flight was also endured by a Russian—not by the Brothers Montgolfier of France.

The Russian additions to the gentle art of making war include the invention of the cannon early in the Middle Ages, and the development of the rolling process for the production of armor plate steel—the latter being the project of Vasili Pyatov in the 1860's. Incidentally, the Russians— not the British—were the first to develop, name, and use the military machine-of-death known as the "tank." Oh yes, we must not forget the inventive genius, Mohammed Andiev, who perfected a mechanical nutcracker that could perform the day's work of 120 men in one hour!

In the field of pure science the Russians have made some of their most spectacular contributions to the total knowledge of the world. Lomonsov—not Lavoiser of France—developed the physical law of the Conservation of Mass; and Darwin was antedated by unknown Soviet scientists in the development of the Theory of Evolution. This theory, by the way, is now considered decadent and counter-revolutionary, and is definitely out of vogue with the Party.

The Soviets also developed the bicycle, synthetic rubber, penicillin, the ball-point pen, the phonograph, "Korn Fleks" (corn flakes, for those who don't do so well in Russian), "Eskimo Pies," and Three-Dimensional Movies, to name but a few.

In addition to this out-and-out inventiveness, the Russians do a fantastic amount of "innovating" (improving on current gadgets, or swiping them from the Western nations) in current production-design engineering. To quote from Eddy Gilmore, *New York Herald Tribune* correspondent to the U. S. S. R.: "The Soviet government has a red-hot campaign going all the time to encourage 'innovators.' An innovator, as far as I could tell, is a fellow who improves on an original device, be it an original Russian machine, or something that has been copied from something in the United States. Substantial prizes are paid for inventions and innovations.

"I remember quite clearly when a fellow came to Moscow from Minneapolis. He was a very intelligent American Negro and he had been working as a postman in Minneapolis. In no time at all after his arrival in Moscow, the Moscow News carried a front-page story and a two-column cut of this man. He had installed something revolutionary in the Moscow Post System. The newspaper story related how, for a few extra kopecks, you could have a letter specially delivered; a man from the post-office would take it immediately, by subway, bicycle, or streetcar, right to your address."

Although this story is certainly not the common rule, it does show the amazing degree to which the Soviet government will go to acquire new inventions and developments. There is definitely a driving force in Russia to outstrip the rest of the world in the development of innovations.

The problem of evaluation of the numerous claims that the Soviet government makes concerning inventions, discoveries, and the like is somewhat more complex than would first be expected. It would be far from correct in all probability, to discount *all* of their claims—for there have been barriers to communication in the past almost equal to the present Iron Curtain, and it is a well known fact that inventions are often discovered simultaneously by entirely disconnected groups of researchers.

It would be even more absurd to accept all, or even most, of these claims; for it is an absolute certainty that Soviet science is subjugated to the Communist Party to a very great extent and is therefore subject to the fluctuations of the Party propaganda line. To be truthful, we must admit that the air—on both sides of the Iron Curtain—is so full of ill-will, hot words, propaganda, and just plain "bull" that the facts are almost totally obscured in the mess! We must therefore depend to a large extent for our information upon reports from the few Westerners who have been allowed inside Russia and who have taken the time to check up—as much as was possible—on the particular claims extant at the time. The reports seem to point towards a policy of general skepticism where Russian scientific discoveries are concerned.

Edmund Stevens, former Moscow Correspondent for the *Christian Science Monitor*, summed up the question in his book, *This Is Russia*, pages 158 and 159. Mr. Stevens wrote:

"By rescuing from oblivion little-known Russian inventors, the party woos Russian national pride. The move corresponds to a vital need of Russians to vindicate their self-respect and destroy the residue of an old sense of inferiority. It also increases the Russians' confidence in their capacity to catch up with and outstrip the rest of the world technically at the present time.

"Having acknowledged success with the atom, the Soviets already are claiming to lead the world in the peacetime use of atomic energy. Before discounting this claim, it is well to point out that the Soviet state, with its centralized and total control of all national resources, including brains and labor power, has important advantages in the atomic research race.

"These considerations do not justify the absurdity of attempts to ascribe all notable human achievements to Russians and the belittling of the contributions of other nations. They merely place the current Soviet claims in their proper historical and psychological context. Moderation is seldom a Russian trait."

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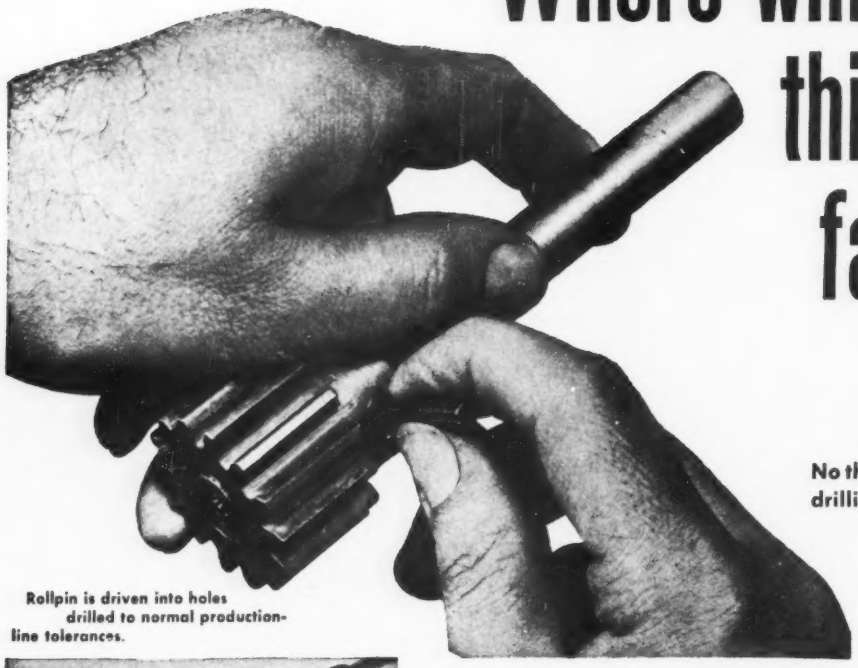

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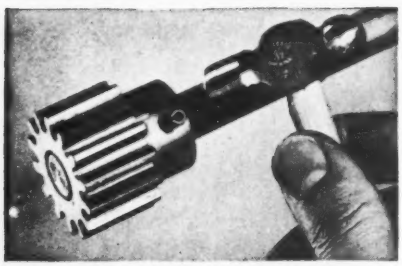

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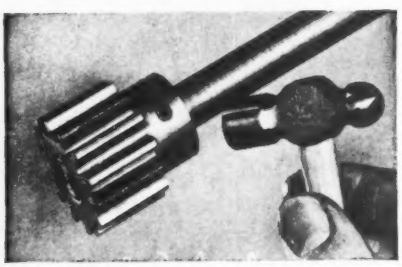

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fresh water from the sea

by Dr. Thomas K. Sherwood

"Fresh Water From the Sea" is an abstract of the address delivered on Sunday, March 21, 1954, by Dr. Thomas K. Sherwood, Professor of Chemical Engineering at the Massachusetts Institute of Technology. Professor Sherwood's address was one of the last of this year's series of Popular Science Lectures sponsored by the Society of Arts at M.I.T.

The idea that there could be a serious water shortage may come to some as a shock. The common complaint is about the excessive rainfall at inconvenient times, and it is obvious that we use but a fraction of the rain which falls in our vicinity. Why not scoop up some of the excess as it flows past us on its way to the ocean? But complaints about too much rain in April and brown lawns in August illustrate the point. The problem is one of distribution in time and space to have the needed water at the right place at the right time.

The average rainfall in the United States is about thirty inches, providing 28,000 gallons for each person each day. This would seem to be much more than enough. But seventy per cent of this evaporates, and one third of the rest disappears underground and can't easily be caught. This leaves 5600 gallons per day per person which we can use if we can catch it. The total water used averages a little more than 1100 gallons per day for each person, so our efficiency in collecting and using the water provided by rain-fall is nearly twenty per cent.

This seems surprisingly high when it is remembered that the rainfall varies so widely over the country and through the four seasons of the year. The utilization is doubtless poor in some parts of the northwest where the rainfall is 120 inches, and very high, indeed, in the southwestern states, where the average fall is less than five inches. The run-off averages somewhat higher per person in the seventeen western states than for the rest of the country, but the use is much higher in the east because of the proportionately higher concentration of industry. An average utilization of twenty per cent means not only very high utilization in certain areas during parts of the year but, inevitably, frequent actual water shortages.

The water problem is already with us. In the first eight months of last year 1031 cities and towns reported enforced curtailment of water use, over half of these instances being due to inadequate supply. The recent experience of New York City is typical, with car washing banned and restaurant patrons requested not to drink water. In almost every instance the shortage was due not to reduced supply, but to increased demand. Between 1950 and 1975 the population is expected to increase twenty-seven per cent, and the water demand to double.

The situation in Southern California is so serious that they not only bring water 300 miles from the Colorado river, but a plan is afoot to transport water the length of the state, from the Klamath river. Ground water is being withdrawn at the rate of 1.4 billion gallons per day in the high plains of West Texas—thirty times the rate of replenishment. Ground water pumping in Southern California has caused intrusion of salt water from the sea. Water-deficient areas are increasing in number and size. Near Chicago the sub-soil water table has been lowered by 500 feet. City after city is limiting the use of water for the cooling of air-conditioning equipment, or requiring its return to the sub-soil. Larger and more expensive reservoirs are being constructed. Three-quarters of the flow of the Missouri at Kansas City last October was released from the Fort Peck Reservoir in Montana. Without this the river stage would have been but two inches above the minimum required for city water and sanitation. No appreciable increase in the country's water supply is in sight, but the need increases steadily.

There are many ways of alleviating the situation, but no simple solution to the problem. More large dams can be built to save water for dry periods. Perhaps cloud-seeding with dry ice or silver iodide can be developed to produce more rain where and when needed. Certain large supplies of brackish waters can be purified at reasonable cost. Sea-coast cities, if necessary, can install a second set of water mains to carry sea water for sanitary and firefighting purposes. More effective re-use of water for industrial purposes, as by the greater use of cooling towers, can save large quantities of water. In this connection it is notable that one oil refinery in Texas re-uses water to the extent that its 600 million gallon per day requirement involves only forty million gallons per day of new water. Since over half of the available water is used for irrigation, there exists the possibility of more municipal and industrial water by reapportionment—at the expense of a reduction in cultivated acreage.

Many of these conservation measures can be effective and important, but the trend of the demand curve makes it clear that in the long run (say 50-200 years) they cannot be sufficient. Why then, not get the needed water from the greatest of all water resources—the sea? Sea water is 96.5 per cent pure water, and directly available to those states in which more than two-thirds of the people live, and in which a somewhat larger fraction of industry is located. One cubic mile of the ocean contains enough pure water to supply the needs of the entire nation for nearly eight days. Many methods of separating pure from salt water are known, and some have been used for centuries.

Sea water contains more than 800 times as much water as magnesium, yet magnesium metal is now obtained commercially from sea water and sold at a profit. Why, then, should not all our water needs be satisfied by producing fresh water from the sea?

The answer to this question is basically simple. We can—at a price. But the significance of the price is not easy to assess. In order to do this it is necessary to compare the probable cost with the water prices we are accustomed to pay. The average price of water for irrigation is in the vicinity of one per cent per 1000 gallons, and large users pay 0.5 cent. Industrial water prices average four to five cents per 1000 gallons, and a typical price for delivered city water is twenty-five cents per 1000 gallons. There may be communities in the southwest which would be glad to have fresh water delivered at fifty cents per 1000 gallons. Very little irrigation water would now be bought for more than ten cents and very little city water at more than forty cents. At the present time, therefore, water from the sea would have to be produced at less than about forty cents per 1000 gallons, though this limit may be expected to increase as the demand for water grows over the years.

In attempting to assess the possibilities of cheap water from the sea, we have one exceedingly valuable guide. This is the second law of thermodynamics, from which we can deduce that the *minimum* amount of power required to separate 1000 gallons of fresh water from sea water is that which would operate a 100-watt light bulb for twenty-eight hours. The "second law" is one of the most reliable laws of nature ever discovered, and it is quite certain that the figure will never be bettered *by any process yet to be invented.*

It is important to understand the significance of this figure. It is the required work energy when operating an ideal process infinitely slowly, with no losses or inefficiencies of any kind. Every real process will require more than the minimum figure —we would be fortunate indeed if we could accomplish the water separation with the expenditure of twice the minimum. Even this is somewhat wishful thinking, since we have no process which even approaches this larger figure.

Thermodynamics suggests nothing about plant costs, except that they may be expected to be infinite if the minimum energy requirement is to be attained. In plant processes of these types the fixed charges usually run about twice the energy costs. On this basis, it appears that about the best that can be hoped for is a total cost of 8.4 cents per 1000 gallons of fresh water. No existing process can approach this figure, but what cost might reasonably be attained?

In order to make an educated guess as to the possibilities of coming close to the target of 8 to 9 cents per thousand gallons, it is necessary to consider some of the methods which may be employed to process sea water for the purpose. Science suggests many methods, but none are very good. If methods now known are to be used the problem is one for engineers rather than for scientists, since energy costs must be balanced against plant costs to obtain the optimum result. Engineering skill and judgment are required, and there is no clean-cut or simple answer to the question of what the minimum practical cost may be. It is possible, however, to estimate the general cost ranges for the various processes with some assurance.

Many processes have been employed or proposed for the recovery of fresh from salt water. Multiple-effect distillation, solar distillation, and vapor-compression distillation are based on boiling, and are already widely used. Chemical methods work, but are expensive, as are most of the electrolytic methods. Ion exchange resins in sheet form can be used to strain out the salt ions with the help of an electric potential. This new resin membrane process and modern vapor-compression units seem to be the most efficient and practical at the present time.

The high cost of getting fresh water from the sea by known and developed processes is discouraging, and the obstacle in the way of progress towards really cheap water is the lack of good new ideas. In this situation the government has wisely allocated a modest amount of money to support research on new processes, with the idea that government support of an inventor's concept in the early stages of its development may carry it to the point where commercial development is warranted. These research grants are administered by the Saline Water Conversion Program of the Department of the Interior. The availability of funds and publicity regarding the problem have already stimulated a number of new and promising ideas, though the program has been under way less than two years.

It is a sad commentary on the state of science that we do not know how to perform the common operation of separating a salt from water without using several times the theoretical minimum power. If the research on methods of purifying sea water leads to improvements in this situation the results will find wide application in many industrial processes.

Although cost figures for producing fresh water from the sea have been suggested for several of the principal processes, it must be admitted that these are little better than rough estimates. Published cost figures for these processes are based on widely varying costs for power and amortization, and the basis for each estimate must be scrutinized before the result can have meaning.

In the earlier discussion two cost targets were suggested: the figure of 8.4 cents per 1000 gallons of fresh water, which might be considered as the ultimate and quite nebulous possibility, and the figure of forty cents per thousand, which is about the top figure which communities now pay.

As the water situation gets progressively worse, water from sea water can be made available at prices which many users will be willing to pay. Processes exist for the alleviation of serious water shortages, albeit the investment in plant will be very large.

The situation in regard to irrigation water is quite different. The average value of the crops produced on irrigated land is estimated to be only ten cents per 1000 gallons of water used, so it seems evident that even if the ultimate target of 8.4 cents per 1000 gallons were reached, and this appears highly unlikely, fresh water from the sea will not be used for irrigation.

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McGRAW-HILL FOR BUSINESS

a new wheel

(Continued from page 29)

Meyer-Drake engines have been well-developed to do this particular task and do it well, but the Ferrari is the most promising foreign entrant at the brickyard since the war, and is a valid candidate for the top ten finishers.

The Kurtis name is also in the news in connection with preparations for the new F.I.A. Formula I, of two and one half liters unblown and three-quarter liters blown. Frank Kurtis is currently at work on a chassis suitable for road racing and for a specially-tuned unblown Meyer-Drake designed to bring back to the States some of the prize money offered in the Grand Prix jousts. Both the racing car and a sports car are to be run, with the young but experienced Boris Said as driver. Looks as if everyone is headed for the greener grass!

Finally, there is considerable speculation about the plans of the irrepressible Briggs Cunningham for the coming Le Mans race, but some things seem certain. He will enter two of the familiar C-4R roadsters with the latest engine and suspension modifications, and is building a new C-6R to take the place of the C-5R, which is now up for sale. The latter vehicle was fast and efficient, but the boss, Briggs, was never happy with the way it handled and cornered. It is highly likely that the new car is powered by a 4.1 liter Ferrari V-12, or an engine specially built along those lines. British authorities think the latter to be the case, but even Cunningham cannot absorb the cost of the construction of a completely special engine. He has tried both the Z.F. and Siata four-speed gearboxes with the Chrysler engines, but a Ferrari powerplant would probably demand a like transmission. The cars from West Palm Beach, then, will also be of interest during the coming racing season.

K. E. L.

a record review

(Continued from page 40)

seventy-eights seem to contain more distortion than should be expected. Most of their recordings have always sounded best with the playback controls set roughly for RCA's new curve; I doubt that London will have to make any changes to conform to the industry standard. However, most of their recordings are not perfectly natural, boosting of the extreme highs gives them a false brilliance that is ever so much easier to take than RCA's shrillness. Before the typical osmium stylus chisels them Londons are the best sounding recordings by far on most cheap phonographs. London has not learned to record thirty minutes on a side without loss of quality—something already achieved by Mercury and RCA, and slowly being accomplished by Columbia. Surfaces vary from really wonderful to bad.

Westminster's orchestral work corresponds to Columbia's, with perhaps a shade less resonance, made up for by slightly more brilliance. You're in the eighth row instead of the twentieth. Their orchestral and choral recordings are consistently fine. Their chamber music sounds as if performed in a large concert hall (exceptions: the Dvorjak and Smetana quartets) with much more resonance than Columbia's chamber music. Many reviewers do not like this sound, but I enjoy it as a welcome change; it is particularly fine for more romantic chamber works such as that of Schuman, Schubert, and Brahms. Pressing is done mostly by Columbia, but surfaces are somewhat better than you'd expect. The NAB curve, needing large amounts of treble cut, is used, except for certain pressings done mostly by RCA, where AES playback is called for on the jacket. I have not heard any of their latest releases that are both pressed by Columbia and recorded to the new RCA curve.

Haydn Society began its activities with musically excellent but miserable sounding recordings. Many of these older recordings sound best on my equipment when I use the 800 cps turnover with bass boost added and the treble completely cut. Their latest recordings contain fine sound, however. Some are pressed by RCA (a guess) and sound fine with AES or the new RCA standard equalization, but most are pressed by Columbia and are identified by the XTV on the record, and require the NAB curve. Surfaces vary all over the quality range on the Columbia pressings, but the others are fine.

As mentioned above, Westminster, Haydn Society, and Columbia have uniformly well balanced, natural sounding recording on almost all recent releases; however, the pioneer in the maintenance of high quality sound on disk recordings in this country (eliminating the need to discuss again London's efforts; they're manufactured in Great Britain) was Mercury, with the Olympian series. This excellence of sound is also available now on their Scandinavian recordings. They combine fine sound with equally excellent pressing techniques, as fine as RCA's, and they are, therefore, at the top of the fidelity pile. AES (again, 400 cps turn over, treble 12 db down at 10kc) works fine on all recent Mercurys, although some of the very latest may actually use the new industry standard RCA curve. Mercury's recording generally favor the brass and percussion; this may, however, be more a function of the compositions and orchestras recorded than of recording technique. Generally the listener seems placed well forward in the second balcony.

Capitol uses the same recording curve as Mercury and makes much over its Full Dimensional Sound. Probably as a result of pressure by distributors the FDS label seems now to be distributed among many recordings not up to today's technical standards, which were previously denied the trademark. Even the very finest Capitol recordings are spoiled by very poor pressing, as are the rereleases from the German Telefunken catalogue. These latter often require great skill to equalize properly; turn over may sound right at 300 cps, or 800 cps, depending on the particular record. The German masters from which these recordings were made were unusually quiet; it is unfortunate that Capitol has seen fit to spoil many of these historically interesting and technically decent recordings with breakfast food: snap crackle pop.

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Other interesting procedures are used throughout Du Pont's many plants to guard against river pollution. For example, scientists were asked to make a complete marine-life census on one river before a plant was built nearby. The company wanted to be certain that no waste would be discharged which would challenge the natural pattern of marine life.

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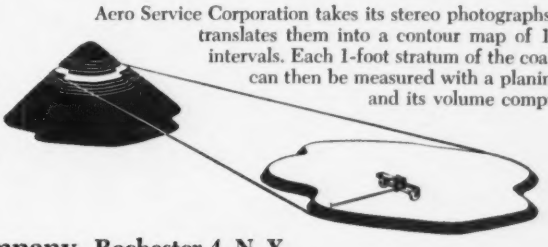
It used to take a surveying crew weeks to measure and figure the contents of the Philadelphia Electric Co.'s big coal piles. Now a camera and an airplane work together to cut the time to days. Overlapping pictures are taken from the air. Then with stereo plotting equipment the volume of the heap is calculated.

Streamlining the inventory job is a natural for photography. It's being used to count metal rods, automotive parts, telephone calls as well as tons of coal. But photography works for business in many other ways as well—saving time, reducing error, cutting costs, improving production.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning service man, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.



Aero Service Corporation takes its stereo photographs and translates them into a contour map of 1-foot intervals. Each 1-foot stratum of the coal pile can then be measured with a planimeter and its volume computed.

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